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March 21, 2003

VIA FACSIMILE AND FEDERAL EXPRESS MAIL

Richard Boyd, Chief
Medium & Heavy Duty Truck Division
Office of Defects Investigation
Safety Assurance
National Highway Traffic Safety
Administration
400 Seventh Street, SW
Washington, DC 20590

RECEIVED
2003 MAR 25 A 10 25

Re: Information Request to SKF USA Inc.
PE02-088

Dear Mr. Boyd:

With thanks for your understanding about the various circumstances that delayed this submission, please accept this supplemental response to the January 31, 2003 response made by SKF USA Inc. to your December 16, 2002 Information Request directed to the company.

Permit me first to correct an error in the January 31, 2003 response. In answer to Request No. 6 at page five, the second paragraph begins, "In June 2000 SKF switched its source of seal supply from its Bethlehem plant to its Elgin, Ill. plant...." That sentence should have read, "In April 2002 SKF switched its source of seal supply...." If a corrected version of the January 31, 2003 submission would not confuse matters, I would be pleased to submit same in substitution for the original. I apologize for the error and trust that it has not adversely affected your investigation.

SKF's January 31, 2003 submission stated that a response to Request No. 10 was in the process of being formulated and would be submitted within thirty days. On March 10, 2003, SKF, as you know, submitted a notice pursuant to 49 CFR § 573.5 reporting the company's determination that some portion of the population of hub units produced within three specified production periods contain manufacturing defects, albeit of a non-safety-related character as evidenced by the absence of any injuries or fatalities involving trucks containing the hub units. As that notice contains SKF's detailed opinion of the "alleged defect in the subject component" and addresses the sub-issues for which an assessment is requested in Request No. 10, SKF incorporates herein by reference its March 10, 2003 letter.

SKF also requested additional time to submit internal and external e-mail communications responsive to Request Nos. 5 and 8. Such documents are being produced with this letter along with the pertinent entries from the calendar of SKF's William Farrell, Vice President, North American Truck Business Unit, and an October 23, 2002 presentation by ArvinMeritor. Although more than one thousand pages are being produced today, additional e-mail traffic is still in the process of being reviewed for responsiveness to ODI's Information Request. On completing that review, we will submit any additional e-mails in SKF's possession that are responsive to the Information Request.

Kindly contact me directly if you have any questions concerning this response or require additional information or clarification.

Sincerely,

David Richman

SKF USA Inc.
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...ck Hub Unit
...ield Investigation
NHTSA Review

23-Oct-02
NHTSA

ArvinMeritor

SKF 001189

Agenda

- Introductions
- Product Background
- Product Description
- Product Performance History Summary
- Initial Problem Investigation
- Truck Hub Unit End of Life Description
- Initial Problem Investigation (continued)
- Initial Problem Investigation Results
- Field Investigation, Phase 1
- Electronic Inspection Device In Use
- Field Investigation, Phase 2
- Next Steps
- THU Predictive Inspection Kit

Product Background

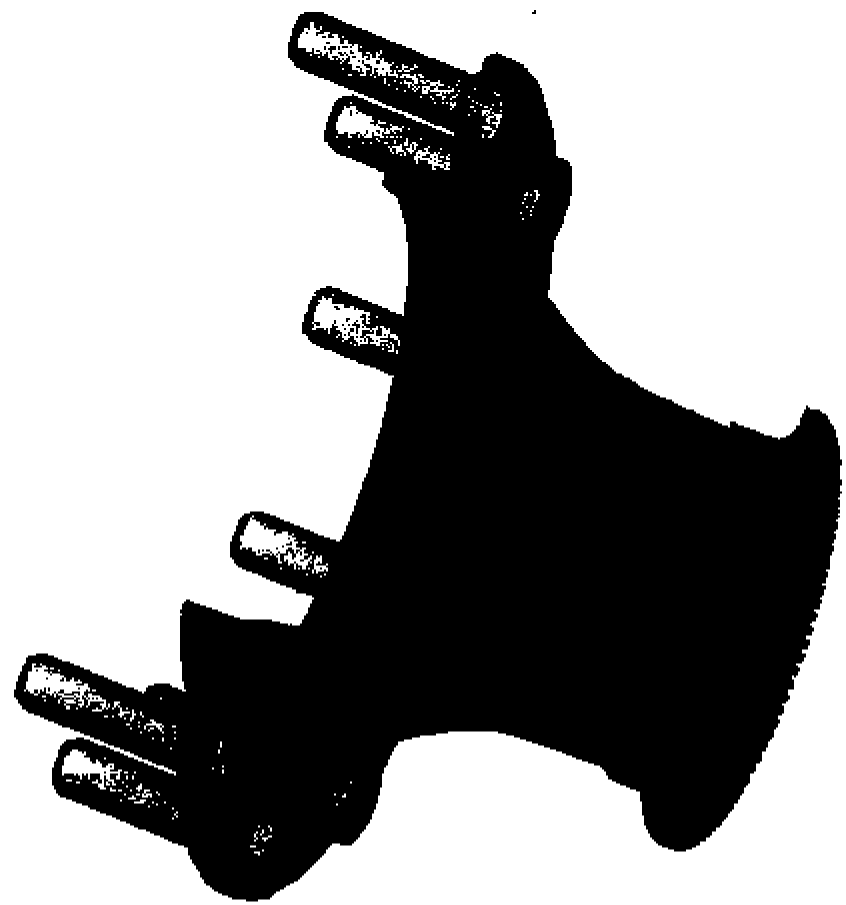
- History
  - Industry Wheel End (THU) Experience ("The Great Wheel Bearing Debate," Commercial Carrier Journal, 2/97, Pg. 49, Paragraph 1) – per NTSB, 750 to 1050 standard wheel end separations per year.
  - Unitized wheel ends (THU) successfully in use in Europe since late 1980's
- Design Criteria
  - Objectives
    - Robust fastening design
    - Sealed, no maintenance, periodic inspection only
    - Warranted for 750,000 miles
  - Application – 12 to 13.2K Line-haul
- Product Introduction
  - 1996
  - Truck Hub Unit produced in Germany, 1996 to beginning of 1999
  - Campaign for flange fracture, all of 1996 vintage replaced
  - Wheel saver campaign (improper field application)
  - Transition to US based production during 1998

Product Description

Hub Sub-System

Consists of:

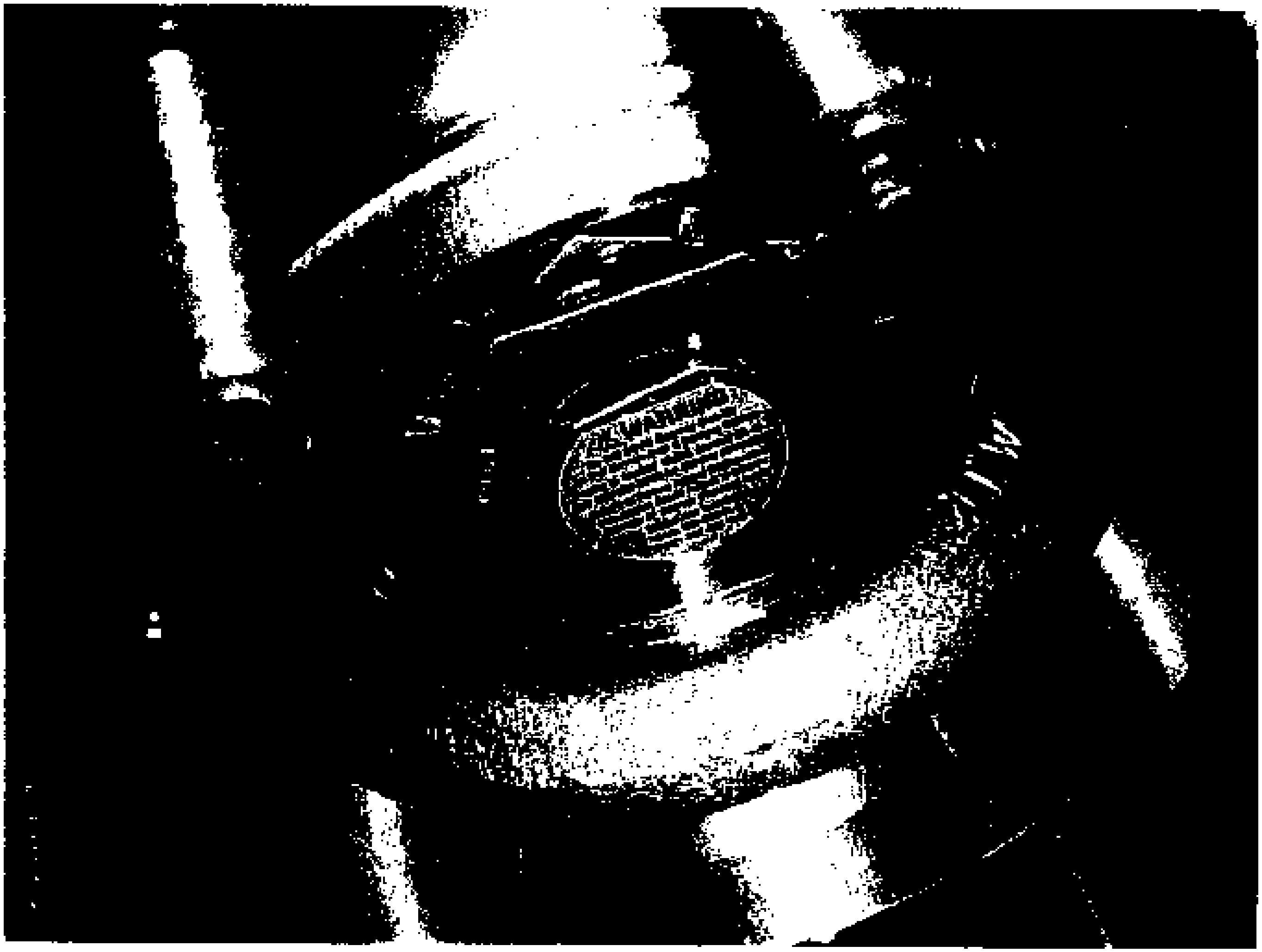
- **Bearing Geometry**
- **Sealed for Life**
- **Long Life Grease**
- **No Maintenance, Periodic inspection only**



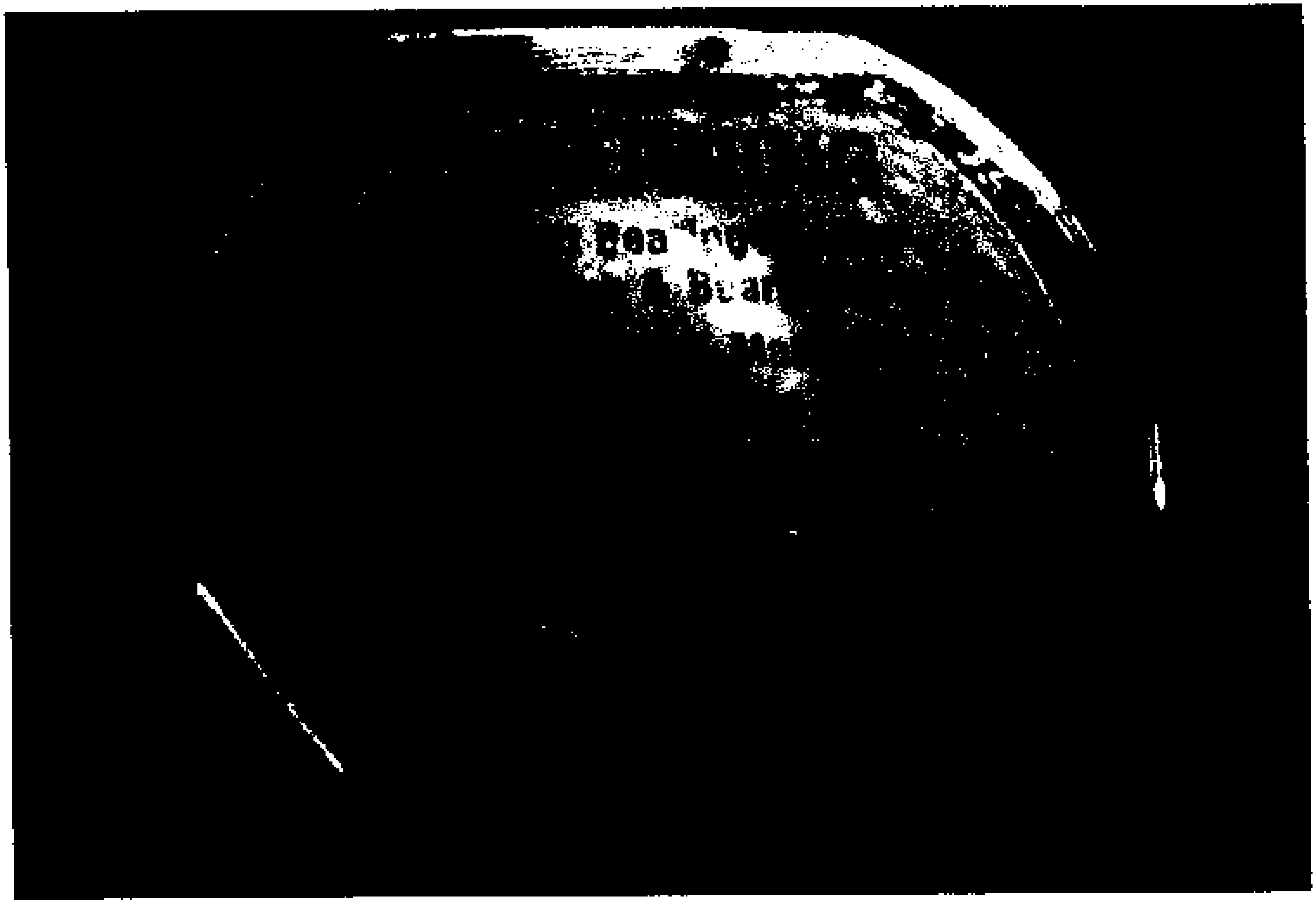
Product Description (continued)

- Robust Fastening System (objective – keep wheel on truck)
  - Large inner "D" Washer and Nut
  - Lock Washer and Outer Nut
  - Tamper Identification
  - Warning Label (proper torque, toll-free number for maintenance information, etc.)
- Product designed to operate in preload
  - New logic as compared to standard wheel end
- Sealed Hub Cap
- Inspection Instructions

Fastening and Tamper ID System



Warning Label - Maintenance



Product Performance History Summary

- Germany production has met expectations
- Product well received in the industry
- United States production issue surfaced during 2000.
  - Problem appeared discrete and contained
- Additional issue surfaced at end 2001
  - Again, problem appeared discrete and contained
  - As a contingency, design investigations and confirmations were undertaken. No significant issues found, only technology upgrade opportunities.
- By Spring 2002, it was apparent that an unidentified issue was in progress
  - Field issues included:
    - Product early wear out
    - Near wheel offs
    - Wheel offs
    - Thermal events

Initial Problem Investigation

- Categorization of problem
  - Retrieve all distressed hubs through warranty system
  - Majority of hubs analyzed for failure reason
  - Symptoms noted (representative list)
    - Oil separation from grease
    - Insufficient preload
    - Water ingress
  - Many root cause theories for the early wear out postulated
    - Inboard seal performance
    - Bearing manufacturing variation
    - Oil separation from grease
    - Numerous others
  - Questions whether wheel offs and thermal events were unpredictable, instantaneous events or were avoidable

Truck Hub Unit End of Life Description

- Path One: Follow recommended Inspection Criteria
  - Vehicle preventive maintenance cycle occurs
  - Truck front end placed on jack stands
  - End play check – if above 0.006", replace Truck Hub Unit
  - Tire rotation check for noise – if vibration or noise is detected, replace Truck Hub Unit
- Path Two: Do Not Inspect
  - Bearing distress progresses towards failure
  - Internal distress causes heat generation – Vibration during braking and turning
  - Wear progression causes increased wheel end play and activation of ABS fault signal
  - Grease and seal failure – Vibration, noise and smoke (Driver halts vehicle or continues)
  - Rollers eject; steering wheel pull, vibration, noise and horsepower increase required (Driver halts vehicle or continues)
  - Brake linings become "bearing" system -- above signs + brake smell (Driver halts vehicle or continues)
  - Heat generation; visible distress signs of smoke and sparks (up to 1600 degrees F)
  - Driver stops - possible fire, or driver continues
  - Fastening system plastically deforms; wheel off, driver stops vehicle

Initial Problem Investigation (continued)

- Actions
  - Manufacturing investigation
    - Axle assembly processes and practices
    - Bearing and wheel end assembly processes and practices
  - Test track test to failure studies initiated
  - Clarity of recommended inspection process improved
  - Field communications to OEM's, Fleets, Owner-Operators
    - Manufacturing issue
    - Introduction to TP-0251
    - Issuance of TP-0298

Initial Problem Investigation Results

- Axle Assembly
  - Minor process changes and modifications incorporated
  - Hub end-play containment instituted
- Bearing and Truck Hub Unit manufacture and assembly
  - Issues leading to early wear-out identified
  - Corrections, both permanent and temporary, instituted
  - End of line containment for effectiveness confirmation Instituted
- Test Track Test to Failure Status
  - Highly accelerated test completed; warning signals present
  - First full test just completed, final report and conclusions due 10/28/02
    - Preliminary Indications are that warning signals are present
  - Second and third test still in progress
- Issuance of detailed, clear and field-tested inspection method (TP-0251)
  - Progressive events reduced but not eliminated
- Field communications to OEM's, Fleets, and Owner-Operators regarding inspection importance and method, as per above.
- ARM/SKF jointly developed electronic bearing failure detection device
- Initial investigation did not answer why progressive events were occurring, as detection of emerging bearing issue is detectable with TP-0251 inspection method

Field Investigation, Phase 1

- Field Investigation Structured, with following objectives:
  - Characterize field population with statistically valid sample
  - Validate effectiveness of TP-0251
  - Verify and validate electronic detection tool and method; choose best option
  - Find answer to why progressive events were still occurring
  - One fleet with multiple locations (7) and in service dates chosen (1997 to 2001).
- Results
  - Electronic detection method chosen and validated; hurdle value established
  - Effectiveness of TP-0251 confirmed (however not as sensitive as the electronics)
  - Field population characterization confirmed TP-0251, but results indicated that the special cause of progressive events was not uncovered.
  - Phase 1 completed on 366 trucks at one fleet, with results suggesting that inspection practices needed to be investigated. Consequently, Phase 2 investigation was conducted at other fleets.

Electronic Inspection Device in Use

SKF 001202

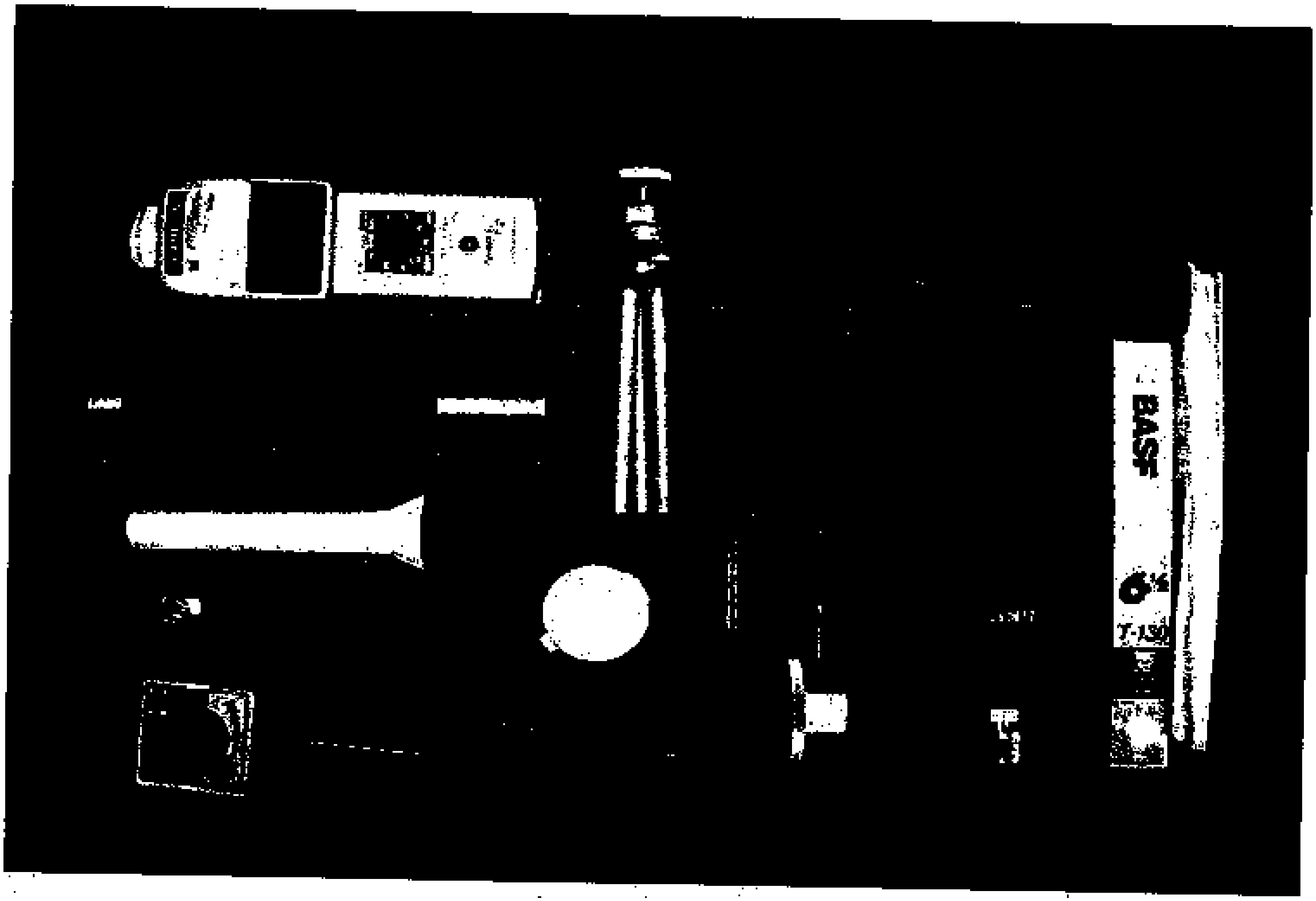
Field Investigation, Phase 2

- Phase 2 investigation structure (scope)
  - Final test of electronics threshold and use instructions
  - Evaluate multiple maintenance and inspection practices (5 locations) – BOB's, average, WOW's (Shainin Statistical Problem Solving Terminology)
  - Specifically target locations with continuing progressive events (definition of WOW)
- Results
  - Those fleets and dealerships that practice TP-0251 do not have significant events
    - No electronic device readings higher than 4.70, which is marginally detectable with TP-0251
    - On-site observation uncovered tools, knowledge and documentation compliance
    - Lack of progressive events after issuance of TP-0251
  - Those fleets/dealerships that do not practice TP-0251 have progressive events
    - Numerous electronic device readings above 11, which is highly detectable with TP-0251
    - On-site observation found lack of tools, knowledge and documentation
    - Concentration of progressive events after issuance of TP-0251

Next Steps

- Final refinement of TP-0251
- Issuance of new Technical Publication for use with electronic detection device for those users that wish to use a predictive inspection tool
- Electronic detection kit availability
- Communications: (May or may not include training)
  - OEM's
  - Fleets
  - Drivers
  - Dealerships (if OEM desires)
  - Owner-operators
  - Maintenance groups (OEM dealerships, fleets, independents)
  - Publications
  - TMC
  - ArvinMeritor/SKF District Service Managers
    - Common purpose is to elevate the awareness of the importance of inspection requirements and methods for end of life determination for this product

THU Predictive Inspection Kit



Discussion

Subject:	**Inspection Report on Parts of "Peak Period" April/Mai 1999**
Category:	

NL02T911.doc

SKF 001206

NL02T911

2002-12-19

Failure Analysis on specially selected Meritor THUs from the Field.

Gunnar de Wit
Materials Theory & Testing
Achim Müller
Business Unit Trucks

CONFIDENTIAL REPORT
Interim Report on Project No. N02403

Failure Analysis on specially selected Meritor THUs from the Field.

NL02T911
2002-12-19

Author	Signature	Proof-reader	Signature
Gunner de Wit / Achim Müller		Armin Olschewski	

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	Name	Group	Location
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	ET report file.		
Internal distribution (electronic)			
Project team members	Gunnar de Wit.	ERC	Nieuwegein
	Achim Müller	Business Unit Trucks	Schweinfurt

	Title	Report No.
Related ERC reports	Avitor Meritor THUs from the Field: Visual inspection.	NL02T903e
	Avitor Meritor THUs from the Field: Scanning Electron Microscopy	NL02M903
	Avitor Meritor THUs from the Field: X-ray Analysis	NL02M904
Key Words	THU	

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SKF 001206

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Failure Analysis on specially selected Meritor THUs from the Field.

Abstract There have been incidents with THUs in the USA. Thirteen run units, taken from the field, were supplied to Schweinfurt for an investigation. The units were specially selected on a production period on which the customer claims that the units are having bad quality. This inspection showed that most of the failed bearings had sufferd, as all previously investigated units, mainly due to poor lubrication conditions as a result of water ingress. In addition several of these units, from this specific production period, showed a poor surface appearance due to an error in manufacturing.

Project background

There have been incidents with THUs in the USA. Several run units, taken from the field, have been supplied to Schweinfurt for investigations.
The thirteen units, investigated and reported here, had been selected from a certain production period, around April/May 1999, when the units had been performed bad according to the customer.

Objectives

To visually inspect the THUs received from the field in order to find an explanation to the high number of claims for the production period mentioned above and to possibly define further investigations.

Main results

One THU delivered had not failed and could still have been used in the field.

Those failed THUs showed a remarkable large number of outer ring failures in comparison to earlier inspected THUs.

The majority of the inspected THUs showed to have been influenced by a mistake in the manufacturing, i.e. there were outer rings which had not been correctly surface finished.

The detailed results of the visual inspection are shown on the following pages of this report.

Main conclusions and recommendations

From the results of the investigations it could be concluded that the high number of claims for the production period of April/May 1999 were caused by an incorrect final operation in surface finishing of the outer ring raceways.

Other potential failure modes, as found earlier on other THUs, see ref. 1, showed to also be present on these THUs investigated and reported here. These were:

1. The application conditions for the THUs were not ideal.

1.a. Poor fit on the shaft, resulting in fretting corrosion in the bore of the inner rings.

1.b. High bending forces on the knuckle and/or shaft, resulted in fretting corrosion on both side-faces of the inner rings.

1.c. Poor surface finishing of the knuckle surface in contact with the inner ring (in-board) had an accelerating effect on the formation of fretting corrosion.

2. Water entering into the THU.

2.a. Resulting in found moisture corrosion.

2.b. Water entered also in to the grease, resulting in poor lubrication conditions, i.e. thin film. This was only supported by the visual inspection and not by the grease analysis. Grease analyses were not conclusive due to the extended storage time of the parts at different locations.

2.c. At one THU water might have entered at the seals as well due to possible malfunctioning of the seal.

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SKF 001209

1. Results of the visual inspection.

In the report below the following abbreviations are used:
IB = in-board, OB = out-board,
IR = inner ring, OR = outer ring.

The whole circumference of a ring is 360 ° with the centre of the loaded zone at 0 ° for the IRs.

Thirteen THUs were delivered to Schweinfurt for analysis. These and some additional information are shown here below in table 1. Only for this report these THUs were numbered from 1 to 13, see the first column.

THU no.	*Code*	*Failed element*	*Miles*	*Remarks (julian date code)*
1	*E1803274*	*inboard IR*	*?*	*12699*
2	*E1800338*	*inboard OR*	*393.580*	*12799*
3	*0036033*	*inboard OR*	*707.854*	*13299*
4	*E1755899 0129336*	*inboard OR*	*228.863*	*12499*
5	*E1741080*	*inboard IR +OR*	*301.130*	*12399*
6	*2169 0122169*	*inboard IR + OR*	*313.970*	*11199*
7	*012217*	*outboard OR*		*11199*
8	*0123238*	*outboard OR*		*11299*
9	*0121351*	*None*	*438.310*	*11099*
10	*2907*	*inboard OR*	*254.250*	
11	*232102 II 2 of 2*	*inboard IR + OR*		*11099*
12	*232102 III 2 of 2*	*inboard IR + OR*	*433.912*	*9-1495*
13	*36-96*	*inboard IR + OR*	*419.811*	

Table 1. Inspected THUs.

The table above is showing that a remarkable high number of the outer rings had failed. Remarkable is also that two of the failures were in the out board position.

One of the THUs, no. 9, had not failed.

The performed visual inspections showed the following features:

1.1 Raceway appearances.

The raceways, contact paths, of the not failed THU, no. 9, showed in general a good appearance, i.e. the bearing could clearly have run longer.

The bearings showed, in general, running tracks being shiny. The shiny appearance is an early stage of adhesive wear or surface distress. This is a strong indication of a not ideal lubrication condition.

One THU, no. 1, had only an inner ring failed. Indication of poor grinding was present.

Five THUs, no's 3,4,7,8 and 10, had only failed outer rings. Indication of poor grinding was visually noticed.

See photograph, fig 1. below, of the typical grinding pattern found on many outer rings. This pattern is giving the indication of presence of grinding burrs. The appearance is very similar to that of the surface in the bore, i.e. a ground and not honed surface. See also further chapter 3.

Two THUs, no's 11 and 13, had failed IR + OR. Indication of poor grinding was visually noticed.

Two THUs, no's 5 and 12, had failed IR + OR. A slight indication of poor grinding was visually noticed.

One THU, no. 2, failed OR, malfunctioning of seal.

One THU, no. 6, failed IR + OR, too far advanced.

THU no's 2, 5 and 6 showed spalls on roller distances which indicates that something has happened during standstill. This could be moisture corrosion, clearly visible on no. 2.

The rollers showed, in general, a (logical) corresponding appearance, i.e. a slightly shiny surface.

For the appearance of the roller ends (in contact with large flange) see chapter 1.4.

Fig. 1. Showing the surface pattern on the raceway of an outer ring. This surface appearance indicates a poor grinding operation.

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1.2 Fretting corrosion.

On several surfaces fretting corrosion was observed, these were:

- inner ring bore. All investigated rings showed fretting corrosion in the bore. This varied from being hardly visible to very strong in appearance. There was a clear tendency that the ring in the in-board position had stronger fretting than the ring in the out-board position. The fretting was, logically, concentrated in the loaded position. However, sometimes the fretting was present around the complete circumference, but, then mostly strongest in the loaded position.
- inner ring side-face, thin section. All investigated rings had fretting corrosion in this position. In some of the rings the fretting was present on the whole circumference. But the general appearance was that this fretting was concentrated (and started) at the positions 90 ° and 270 °.
- inner ring side-face, thick section. All investigated rings showed to have fretting corrosion in this position. In most of the rings (9 out of 13) the appearance had a specific mode which could be related to the poor surface finishing of the corresponding surface on the knuckle.

1.3 Moisture corrosion.

Corrosion, most probably due to the presence of water, was found in the following positions:

- inner ring bore, contact surface with shaft. This "normal" red rust was found on almost all rings.
- inner ring bore, thin section. This corrosion was found, on 5 rings, in the position where the load had been applied, 0°, which indicates that it occurred during stand-still.
- on the shoulder of IR large flange. This was only found on one inner ring, in THU no. 2 in table 1.

1.4 Sliding/wear.

Sliding with resultant wear (smearing) was observed at the surface contact between the roller end and the large flange. All investigated rings showed to have this. Some showed to have small spalls, i.e. material broken out.
The roller ends showed in general a shiny surface, i.e. early stage of adhesive wear.

1.5 Seals & shoulders in contact.

As a result of the sliding of the seals on the shoulder of the large inner ring flange, shiny bands were noticed on the rings. This is regarded as a normal and acceptable appearance.

1.6 Other remarks.

"Nick" type indentation was found on the roller raceways. However, there were no signs that these have influenced the performance of the bearings.

The appearance of the bolts was not inspected.

2. Results of the grease analysis.

Grease samples from nine failed THUs in table 1 have taken, analysed and reported in ref. [2].

The conclusions were:
- All grease samples investigated could be indentified as grease Calithia EP2.
- The oxidation and alteration of the grease is moderate.
- All grease samples are polluted by more or less iron oxides (rust) and over-rolled steel particles from the bearing.
- One grease sample, from THU no. 2 (E1800338), contains an extraordinary amount of iron oxides, 3.16 weight %, including metallic particles and some inorganic silicates.
– No water could be detected, neither by Infrared nor by applying the simple crackle test.

3. Results of the metallurgical investigation.

Seven of the THUs were sent to the materials laboratory, in Schweinfurt, for a metallurgical investigation. The outcome of this, reported in ref. [3, 4], was as follow:

- Hardness, effective case depth after induction hardening and microstructure are within specifications.

- Etching of the observed pattern on the outer ring raceways for grinding burns showed that all features are within specification and are not a cause of rejection.

- In some cases, a fundamental reason for the reduction of service time is corrosive damage of the OR raceways.

- A further feature especially of the OR-IB raceways is the missing or totally inadequately honed raceway surface. Their cause is the grinding process. It is known from literature that just ground surfaces show considerably lower surface life when compared with honed surfaces. In, ref. [5] 10 times faster materials aging of ground compared to honed surfaces is reported. It can be assumed that just ground raceway surfaces reduce the maximum endurance life by 50 to 90 %.

Details of this investigation are given in tables 2 and 3 and pictures 2…5 (see chapter 5. Tables and Pictorial)

4. References.

[1] G. de Wit, *"Avitor Marlor THUs from the Field: Visual Inspection."*, ERC Report no. NL02T903e.

[2] C. Greubel / R. Kuhl, *"Determination of Condition and appearance of grease samples from BTH-0052."*, Test Report No. C458/02.

[3] STW3/NI/DU/DrGe/De, *"Inspection report No 281/02"*

[4] STW3/DrGe/Ni/DU/De, "Untersuchungsbefund Nr. 306/02"

[5] N. Tsushima, *"Changes in X-ray Parameters with Loading Cycles in Rolling Contact in Various Through-Hardened Steels"*, NTN contribution ASLE transaction, May 1987.

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5. Tables and Pictorial

OR-IB	P232/02			P250/02		P247/02	
	THU 13	*THU 11*	*THU 12*	*THU 3*	*THU 4*	*THU 1*	*THU 7*
No.	36-96	"Claim"	9-1495	0036033	E1755899	E1803274	2907
Origin	Wal-Mart	Wal-Mart	Wal-Mart	Ryder	Freightliner	unknown	unknown
Miles	499.811	unknown	433.912	707.854	228.863	unknown	254.250
Ground (not overrolled raceway ends)	yes (both raceway ends)	yes (both raceway ends)	yes (both raceway ends)	yes (both raceway ends)	yes (both raceway ends finely ground)	yes (both raceway ends)	yes (both raceway ends finely ground)
Honed	no	no	no	no	no	no	no
R_a [µm], rim	0.73	not measured	not measured	0.56	not measured	0,52	0.60
Machining structures visible	smoothed, visible	smoothed, visible	smoothed, visible	heavily smoothed, partly visible	slightly visible, heavily polishing wear	partly visible, smoothed,	clearly visible
Corrosion	yes (esp. within grinding marks)	yes (slight)	yes	yes (slight)	yes	yes (medium)	yes (medium)
Chatter marks	not visible	not visible	not visible	yes	yes	yes (slight)	yes
Spalling	2, axial, roller distance	2, axial, roller distance; several micro-pits	yes (many)	2, axial, roller distance	2 micro-pits in roller distance	1, axial; several bands with micro-pits	1, axial; line-shaped bands with micro-pits

Table 2: Observations on inboard outer ring raceways

SKF 001212

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OR-OB	P232/01			P258/02		P247/02	
	THU 13	*THU 11*	*THU 12*	*THU 3*	*THU 4*	*THU 1*	*THU 7*
Nr.	36-96	"Claim"	9-1495	0036033	E1755899	E1803274	2907
Origin	Wal-Mart	Wal-Mart	Wal-Mart	Ryder	Freightliner	unknown	unknown
Miles	499.811	unknown	433.912	707.854	228.863	unknown	254.250
Ground (not overrolled raceway ends)	yes (both raceway ends)	yes (both raceway ends finely ground)	yes (both raceway ends finely ground)	yes (both raceway ends)	yes (both raceway ends finely ground)	yes (both raceway ends)	yes
Honed	no	no	no	yes (both rims)	no	no	yes
R_a [µm], rim	not measured	not measured	not measured	0.13 … 0.37	not measured	0.49…0.59	0.21
Machining structures visible	differently smoothed, visible	polishing wear, partly visible	clearly visible, slightly smoothed	partly visible, partly polished	weak ripples, heavy polishing wear, slightly visible	partly visible, polishing wear	clearly visible
Corrosion	yes (heavy)	yes (heavy)	yes (medium)	yes (medium)	yes (heavy)	yes (heavy)	only very slight
Chatter marks	slight	slight	slight	extremely slight	no	yes	no
Spalling	line-shaped micro-pits	no	no	no	no	no	no

Table 3: Observations on outboard outer ring raceways

Picture 2: SEM picture of ground only inboard outer ring raceway of THU No 1

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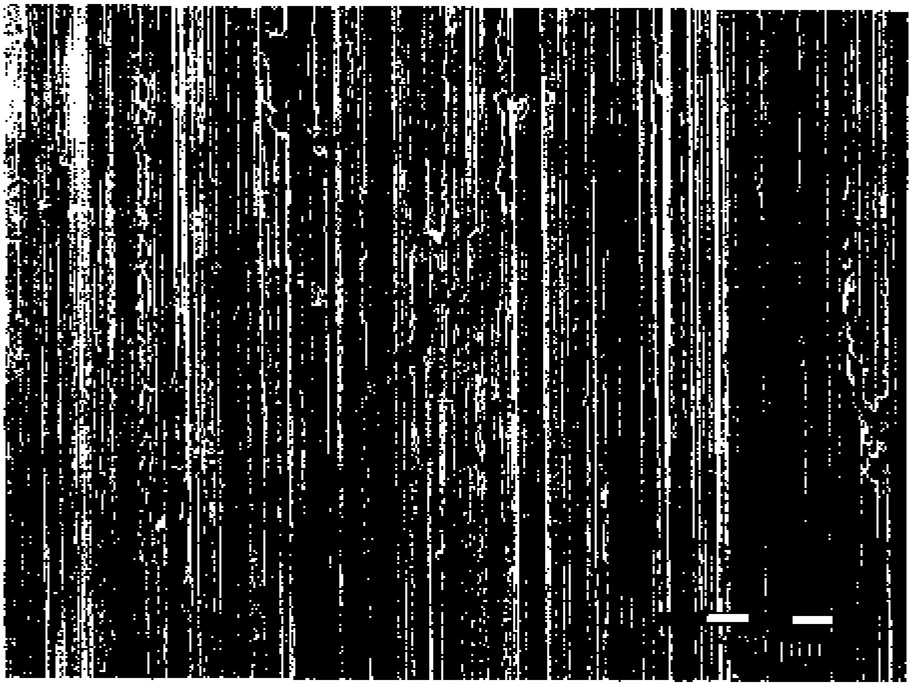
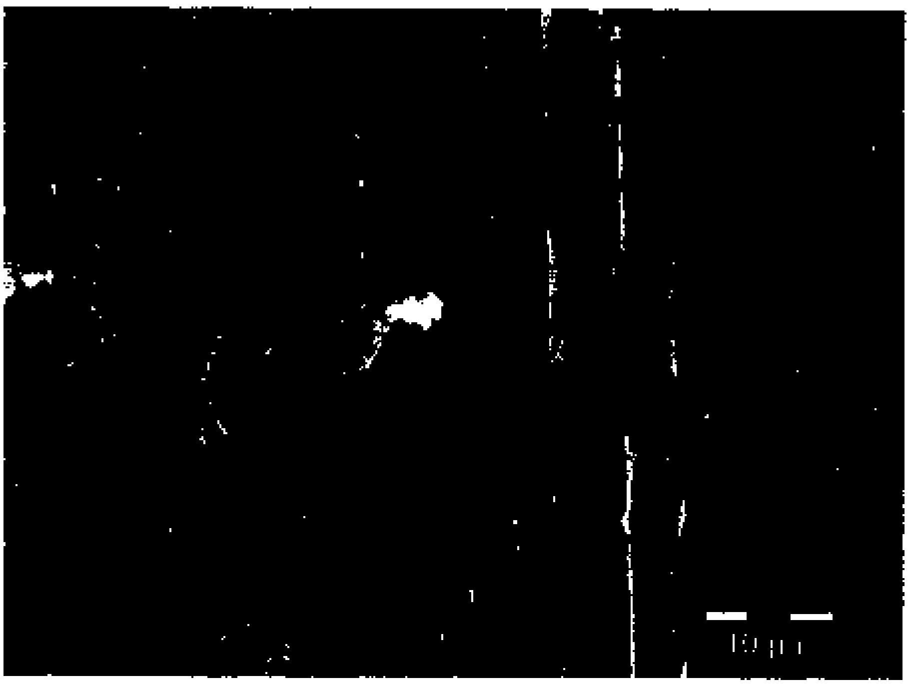


Picture 3: Overrolled grinding structure (detail of picture 2)



Picture 4: Overrolled corrosion pittings (inboard outer ring raceway THU 4)

SKF 001214

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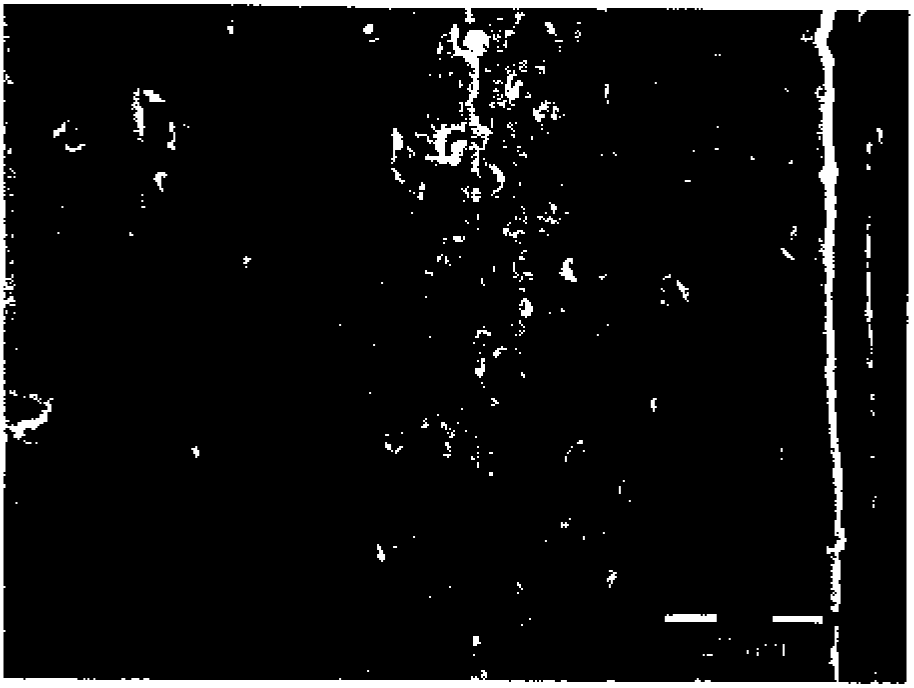

Picture 5: Circular damage pattern (inboard inner ring raceway THU 4) similar to current flow damage

SKF 001215

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Discussion
Main Topic:
Michael D Lewis/DET/SKF
11/26 11:03 AM

Subject: ARM/SKF meeting Nov 21 2002 - April/May 99 issues

Category:

To all:

Bob Bondy and I met with Dale Bell (Engineering), Chuck Smith (Quality), Tom Sanko (Marketing), and Kim Lang (Purchasing) at 2 p.m. on Thursday, November 21 to discuss the poorly honed outer ring raceways from March/April 1999.

The overall reaction was positive - the material from the investigation was logical and seemed to make sense. The presentation material is attached and on the ARM Notes database.

The following were the major points made and the major action items:

A high number of the returned parts had OR spalls and badly honed raceways on the outer rings.

There were 6113 units produced on the days in question in April and May.

We don't fully understand the root cause for poor honing yet - there are several potential issues from this time frame. We asked for another 2 weeks to fully investigate this issue.

We have very limited data on the outer ring through August of 1999

We were unable to find any data on raceway surface finish traces and have only MEF traces (for form) which give an indication of surface finish.

We have records of MEF traces approximately once or twice a week.

MEF traces indicate a problem From April (steer set-up) to Mid - May 1999

Failure mode is similar to all others.

50,000 mile inspection interval is sufficient to pick out failures.

We recommended continuing to look at specific high failure dates to identify all root causes.

We have 2 units with unhoned outer rings on test (which have since failed at 230 hrs).

ARM comments and questions:

ARM is looking to SKF to prove that the failure progression is the same as other failure modes - (by rig test if possible ?)

Chuck Smith asked for information on an 8D format - Due Nov. 25th. (Claes and Juergen - need your feedback from the drafts I have sumitted).

Dale Bell asked what the material removal was from the honing operation (Aiken please advise).

Why is the vibration of a complete unit (IR and OR) checked on the car lines but not the truck line (IR only) ?

Is the operator at the axial clearance rebuild station trained to look for honing/grinding issues ?

Has honing or grinding issues ever been found at the axial clearance re-work station ? (It was non-functional during this time period).

How does the control plan for Aiken differ from Luchow for the OR ?

On a somewhat separate issue:

Dale Bell informed us that their unit on test at Bosch has shown a sudden increase in endplay (at 140,000 miles)- from 0.016" to 0.032" in 1000 miles. This may mean that the end of life is more sudden than we have previously believed. Due to the mixed data, they have asked for our status on Phase 2 of the SWRI testing - we are currently waiting on the purchase order approval. We need approval to get started.

Regards,

Mike

April May 1999 rev2.pp

Peak Warranty Periods

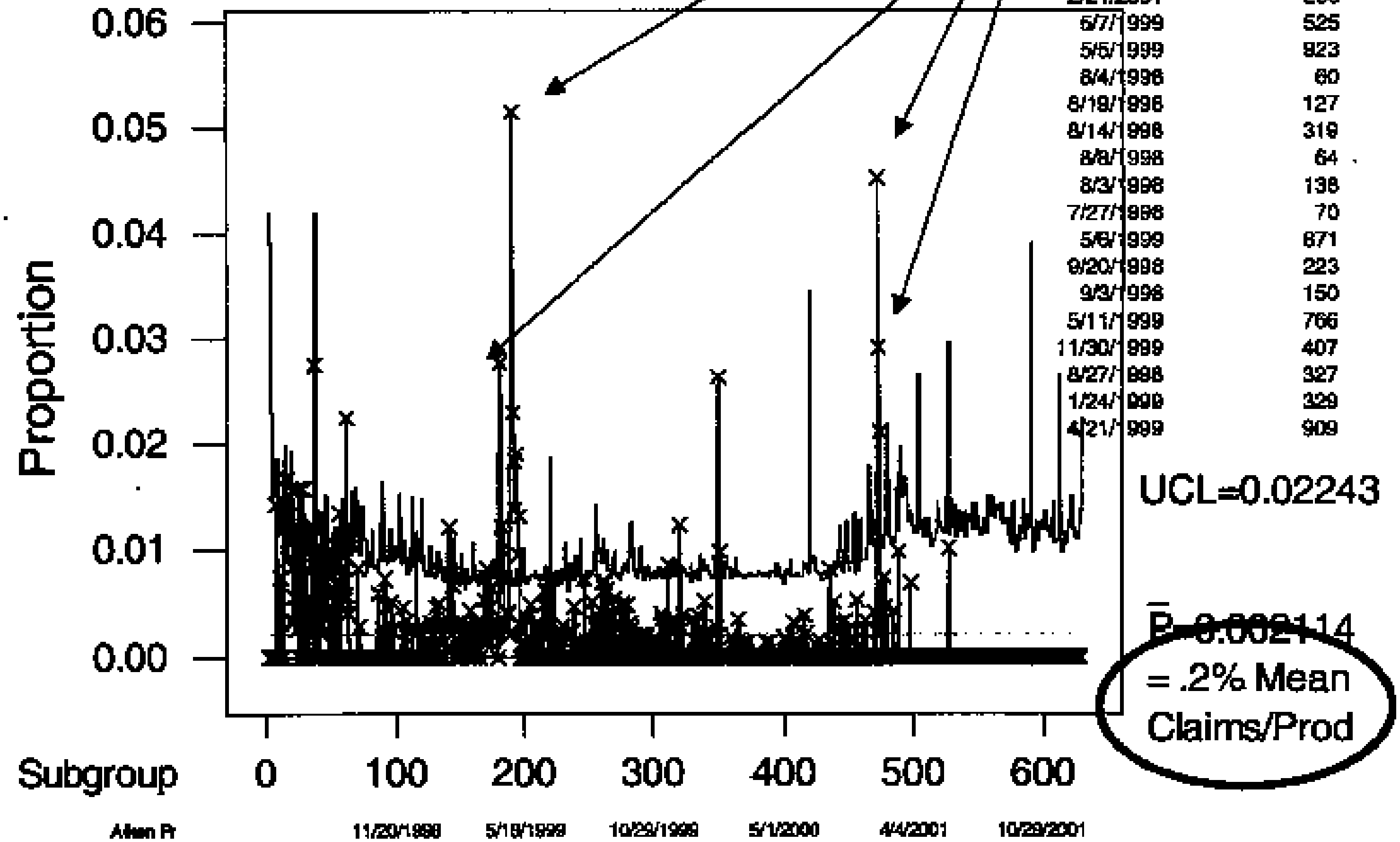
April/May 1999
Investigation Results

SKF 001216

Failure Rate by Day

Aiken Production Date	Aiken Production Qty	Warranty Claims	Proportion
5/3/1999	583	30	5.1%
2/19/2001	177	8	4.5%
2/20/2001	208	6	2.9%
4/20/1999	796	22	2.8%
8/29/1998	182	5	2.7%
2/21/2000	38	1	2.6%
5/4/1999	740	17	2.3%
9/25/1998	267	6	2.2%
2/21/2001	236	5	2.1%
5/7/1999	525	10	1.9%
5/5/1999	923	17	1.8%
8/4/1998	60	1	1.7%
8/19/1998	127	2	1.6%
8/14/1998	319	5	1.6%
8/8/1998	64	1	1.6%
8/3/1998	138	2	1.4%
7/27/1998	70	1	1.4%
5/6/1999	871	12	1.4%
9/20/1998	223	3	1.3%
9/3/1998	150	2	1.3%
5/11/1999	766	10	1.3%
11/30/1999	407	5	1.2%
8/27/1998	327	4	1.2%
1/24/1999	329	4	1.2%
4/21/1999	909	11	1.2%

P Chart Proportion Claims Daily Against Hub Production Qty



SKF 001219

18 Units Inspected

- 110 – April 20 (9 parts)
- 111 – April 21 (3 parts)
- 112 – April 22
- 123 – May 3
- 124 – May 4
- 126 – May 6
- 127 – May 7
- 132 – May 12

Findings

- One unit failed due to an inboard seal failure
- One unit was NTF (5/3/99 part)
- Seven units were too advanced to determine root cause
- Remaining 9 units show common issue:
  - Outer ring spalling
    - Most inboard, some outboard
  - OR raceway appearance

Unusual Pattern in Outer Ring Raceway

Significant Events.

- Very limited outer ring data for Jan – July 1999.
- No surface finish data found.
- MEF data indicates poorly honed raceways both inboard and outboard.
- On May 14 th issue with honing stone sensor corrected.
- June 1999 honing counter added to replace above sensor.

APRIL 20TH – MAY 28TH 1999
OUTER RING MEASUREMENT RESULTS

DATE	INBOARD RACEWAY	OUTBOARD RACEWAY
April 20th	OK	Not OK
April 21th		
April 22nd		
April 23rd		
April 25th		
April 26th		
April 27th	Not OK	Not OK
April 28th		
April 29th		
April 30th		
May 1st		
May 2nd		
May 3rd		
May 4th		
May 5th	Not OK	OK
May 6th		
May 7th		
May 8th		
May 9th		
May 10th		
May 11th	Not OK	OK
May 12th		
May 13th	OK	OK
May 14th		
May 15th		
May 16th		
May 17th		
May 18th		
May 19th	OK	OK

SKF 001225

Future activities

- RQ test un-honed OR parts (underway)
- Sort returns by day or time period
  - Focus on start up, other peak days
  - Continue confirmation of root cause of Feb 2001 returns (seal issues)
  - Sort for defective honing pattern in returns (confirmation of corrective actions and time periods affected)

What to do with the parts in the field ?

- The observed defects would lead to a reduction in fatigue life.
- The failure progression/rate of deterioration will be the same as that observed on road and track tests conducted on returned parts.
- The program of 50,000 mile inspection intervals is sufficient to permit timely detection of any possible premature hub unit failure that might be caused by improper honing.

Discussion

Subject: Inspection of "Peak Date" Truck Hub Units

Category:

The attached document is a draft report about the findings on a total of 10 parts from the "peak period" between April, 20 and May, 07 1999.

sl021216.doc

INSPECTION OF RETURNED THUs

SKF GmbH
Gunnar-Wester-Str.12
D-97419 Schweinfurt, Germany
Tel.: +49 (9721) 56-0

Ohne unsere Genehmigung darf dieser Bericht weder vervielfältigt, noch dritten Personen oder Konkurrenzfirmen mitgeteilt werden (§1 des Gesetzes vom 9.September 1965).
Without prior consent this report must neither be copied nor communicated to a third party or competitors (§1, act of 9th September, 1965).

Requested by **Requester**

Project Project Titel

Reported by	Supervised by	Approved by
Achim Müller/ATT-D		A. Scubenrauch / ATT

Copies to

Michael D. Lewis	ADNA	SKF NATC
Achim Müller	ATT-D	SKF Schweinfurt
Archiv	MWI	SKF Schweinfurt

Content

Key words: ArvinMeritor, Truck Hub Unit, Inspection

Purpose of the Inspection

SKF THU2 are experiencing an unacceptable level of bearing damages in Northern America. Evaluation of recordings of the operation time ("Months in Service") reveals a distinct peak with an accelerated damage rate of products manufactured between April 20, 1999 and May 6, 1999.

SKF personal was able to collect a total of 18 parts produced in and around mentioned time frame. This report covers the visual inspection of 10 of these parts, which have been sent to Schweinfurt for detailed investigation.

Findings of Visual Inspection

Hereunder are listed the findings and conclusions of the visual inspection performed in the Schweinfurt test laboratory. To identify individual bearings, the findings are summarized under the respective claim number, manufacturing date code (e.g. 11199 stands for the 111. day of 1999, i.e. April 21, 1999) and mileage (were given).

E1803274 12699 ? miles

The inboard outer ring raceway shows two spalls. Both outer ring raceways show patterns similar to those expected in the presence of grinding defects. The inner ring raceways are dented from overrolled particles. The inboard inner ring bore shows heavy corrosion. Corrosion and knuckle witness marks are visible on the inboard inner ring large side face.

Picture 1: Grinding defect pattern on outboard outer ring raceway

E1800338 12799 393,980 miles

Inboard outer ring raceway shows three large and several smaller spalls in roller distance. All working contact surfaces are covered with a reddish layer indicating corrosion. The raceways of inner and outer rings show signs of abrasive wear, there are however multiple axial lines visible indicating contact corrosion during standstill. The inboard seal lips are heavily worn, the seal counterface is heavily corroded over about 90°.

0034033 13299 707,854 miles

The inboard outer ring raceway exhibits two spalls. Signs of grinding defects are visible. All other raceways appear only damaged by overrolled particles. The inner ring bores show corrosion. Witness marks of the knuckle and corrosion are present on the large side face of the inboard inner ring.

E1755899 12499 228,863 miles

The inboard outer ring raceway has a single small spall. Signs of grinding defects are visible. The inner ring bores are corroded, the large side face of the inboard ring is also corroded, witness marks of the knuckle are visible.

Summary

A total of 10 returned bearings have been inspected. All of those bearings had been identified to be manufactured during a time period with elevated warranty claim rates.

Claim number 0121351 is classified to be invalid, no damage whatsoever has been found on the ring and roller raceways. Claim number E1800338 has been classified to be caused by an inboard seal damage. No further investigation is performed on those two bearings.

On claim numbers E1741080 and 2169 the damage progression is found to be advanced such, that no reasonable root analysis of the root cause of the failure mode is possible.

All other claimed bearings are exhibiting patterns as expected from grinding defects. Upon further investigation, this assumption could not be proven. There is, however, evidence of a poor or even completely missing honing operation of the outer ring raceways. It is known from literature (N. Tsushima, "Changes in X-Ray Parameters with Loading Cycles in Rolling Contact in Various Through-Hardened Steels, NTN contribution ASLE transaction, May 1987) that a 10 times faster material ageing of ground surfaces compared to honed surfaces can be expected. Thus an reduction of bearing life up to 90% may be assumed.

On almost all inspected parts a potential water leak path through the joint between inner ring and knuckle and along the spindle is found. Similar findings have been reported already in ST02T206.

It has to be noted, that these hard machining defects were observed now the first time during all inspections in conjunction with ArvinMeritor's claims. Based on the amount of observed grinding damages, it may be assumed that the hard machining processes of outer ring raceways has had an issue during the critical time period in April/May of 1999.

Subject: Freightliner Visit Report on 11 Nov 02

Category: Information

Thomas.Sanko@ArvinMeritor.com on 11/14/2002 04:21:36 PM

To: Dale.Bell@ArvinMeritor.com, Charles.Smith@ArvinMeritor.com, Bradley.Arnold@ArvinMeritor.com, robert.j.bondy@skf.com, william.j.farrell@skf.com, Michael.D.Lewis@skf.com, Thomas.Rogers@ArvinMeritor.com, Ken.Santschi@ArvinMeritor.com
cc: Peter.Donnelly@ArvinMeritor.com
Subject: Minutes from Freightliner 11-11-02 meeting

11-11-02 meeting.doc

Freightliner/ARM/SKF Unitized Hub Meeting
Portland, Or. 11-11-02

Attendees:

Steve Payne	Chuck Smith	Bill Farrell
Tim Blubaugh	Brad Arnold	Mike Lewis
Tony Moore	Tom Sanko	
Carlos Billingsly	Dale Bell	
Steve Ellison	Ken Santschi	
Floyd Frick	Tom Rogers	
Terry Watkins		
Dale Rodabaugh		
Dan Fuchs		
Lauren Keplinger		

Chuck Smith presented the material developed from the field investigations through phase 1 and phase 2.

The meeting was opened to questions and discussion regarding the data.

Comment: Tony Moore—asked for the rework details for the axial clearance gage.
Action: Mike Lewis to provide details to Dale Bell for transmittal to Tony

Comment: Dan Fuchs—what warranty is offered by other OEMs on FF98X?
Action: Tom Sanko to determine and provide to Dan.

Comment: Tim Blubaugh—why do we think another mailing will be any more effective than the first?
Response: First, we believe the issue is important enough to warrant the expense of another mailing. Secondly, we expect to improve upon the effectiveness by using personal visits from our DSMs to deliver the materials to the top 100 fleets and dealers.
Action: Tom Sanko to proceed with the mailing as planned.

Comment: Dan Fuchs—we must be sure to get to every owner.
Action: Our mailing will be to the customer lists provided by each OEM.

Comment: Tim Blubaugh—is the 50k inspection interval sufficient or should it be shorter?
Response:–Dale Bell reiterated that the test track unit has accumulated 75,000 additional miles since initial detection by an unbiased technician using TP-0251. At 50k mileage intervals, one additional inspection would have been performed where the indication of a distressed hub would be even more apparent.
Action:–none

Comment: Tony Moore—questioned the detection time available to the driver from onset to significant event.
Response: Dale Bell—test track evaluation has demonstrated the hub has the capability to accumulate a minimum of 75,000 additional miles from initial detection.
Action: none

Comment: Tony Moore—we have sent TP-0251 out already, why are we continuing to have problems?
Response: Dale Bell—any new technology requires some level of training. Our field investigation has revealed a wide range of maintenance practices among shops.
Action: none

Comment: Tim Blubaugh—this meeting is no different than previous meetings since March 02, .. .inspect, inspect, inspect, with no definitive alternative and, in Freightliner's opinion, no acceptable solution proposed.
Response: Chuck Smith—the ultimate 'end of life' situation is no different from the current situation. If the 'end of life' of the hub does not exceed that of the truck, the hub will fail and may result in a highly progressed incident. Regular properly performed inspection is the only current method available to prevent such failures.
Action: none

Comment: Tim Blubaugh—what conclusions have we drawn from our field data?
Response: Chuck Smith—a definitive root cause is still to be identified by SKF.

Mike Lewis—SKF is currently finalizing some recent findings as a result of trip by Mike to Germany. A few weeks are required to complete the analysis.

Brad Arnold—we need an additional (60) days to further evaluate (3) suspect production time periods and determine if action beyond inspection is warranted.

Action: Tom Sanko to establish a follow up meeting for mid Jan.

Comment: Tim Blubaugh—a 'known defect' must be recalled from the population, especially if a serious problem can occur.
Response: Brad Arnold—there have only been (58) total significant events from a population of 400,000 hubs.
Action: none

Comment: Freightliner wants an electronic tool kit sent to their Utah facility.
Action: Tom Sanko to arrange for the delivery of (1) kit and and training of technicians.

Comment: Tony Moore—how are we ever going to go back to 200,000 mile inspections?
Response: Dale Bell—we may suggest a time period where trucks of a given build date can use 200,000 mile inspections whereas trucks prior to that date would retain the 50,000 mile inspections.

Carlos Billingsly—that would be very impractical for fleets with mixed vintages.

Comment: Tim Blubaugh—regarding the driver warning label, why not replace all of the driver warnings with —-this truck is equipped with unitized wheel ends that should be inspected per TP-0251 every 50,000 miles.
Response: Tom Sanko—the purpose of the warning is to make the driver aware of conditions indicative of a developing highly progressed incident. To tell the driver to inspect the hubs is not appropriate if his sole responsibility is to drive the truck.

Brad Arnold—this is a good comment and we will consider it.

Action: Tim Blubaugh to circulate the proposed wording within Freightliner for comments, and to respond to Sanko.

Comment: Dan Fuchs—are we going to cover service centers with our mailing or just fleets?
Response: Tom Sanko—Truck Stops of America, PETRO Truck Stops and possibly others will receive the mailing.

Dan Fuchs—if Freightliner does the mailing, the Freightliner Select Truck Centers for used truck sales will receive the mailing. If we mail, Freightliner will have to provide the mailing address information.
Action: Tom Sanko to coordinate the mailing of the literature.

Comment: Tony Moore—does Ryder have a different failure rate by OEM on those that we inspected?
Response: Dale Bell—Ryder calculated that and provided it to us.
Action: Tom Sanko—submit information to Tony Moore.

Comment: Tim Blubaugh—we should continue to hold conference calls every Friday beginning with this Friday.
Response: Dale Bell—we will only have the test track data to share this Friday.
Action: Dale Bell and Tom Sanko will initiate the Friday conference calls on 11/22.

Tom Sanko

Discussion

Subject: ARM NHTSA meeting 23OCT02

Category: PLB

Robert J Bondy
10/25/2002 02:39 PM

To: Richard W Frett/ELG/SKF@SKF, Tom Johnstone/GHQ/GOT/SKF@SKF, William J Farrell/ELG/SKF, Bernd Stephan/SCH/SKF@SKF
cc: Michael D Lewis/DET/SKF@SKF, Bruce Weeks/AMER/SKF@SKF, Achim Mueller/BCH/SKF@SKF, Arno Stubenrauch/SCH/SKF@SKF, Edward F Cotter/AMER/SKF@SKF, Christopher Jones/AMER/SKF@SKF, Claes Rehmberg/GHQ/GOT/SKF@SKF
Subject: NHTSA Debrief with Chuck Smith

This will also be on the ARM database.

NHTSA Attendees 4 people:
Tom Bowman; Dick Boyd; NHTSA legal council - Loyd?; NHTSA Egineer previously from Peterbuilt;
Names of NHTSA legal council and the NHTSA engineer are forthcoming
Note that Tom Bowman worked for ARM as product safety specialist

ARM Attendees:
Jack Rice - Former NHTSA legal council, Peter Donnelly, ARM legal Council, Chuck Smith, Director of Quality.

The meeting lasted for 2 hours instead of the originally scheduled 1 hour

- NHTSA closed the meeting by stating " **You have brought a significant event to our attention.**" and that this situation would require more thought and analysis
- NHTSA asked ARM if they needed any help getting resolution from SKF. ARM stated that as a supplier to them, SKF was their responsibility.
- ARM also mentioned that it was their decision to make this presentation without SKF.

General
- They presented the presentation that we reviewed with some of the revisions we requested
- They mentioned that German (Leuchow) production met expectations - specifically less than 1 % of the parts failed before 750,000 miles.
- Aiken production (Firestone is also located in Aiken) has a higher failure rate attributed to the following several process issues:
  1. Monson/axial clearance
  2. Unhardened raceways
  3. SKF Process issues
- Chuck mentioned that SKF has too much process variation in Aiken, however, it is under better control today.

Product Issues:
- Fleets that use inspection procedures (TP-0251) are not having progressed incidents. Those that do

not inspect the units have issues.

- NHTSA recognizes that there is an issue with end of life with this product.
- NHTSA mentioned that while they understand that the product is warranted for 750,000 miles ARM is responsible for the safe performance of the product through its lifetime. This led to the question what do you do when a truck has been sold to a third owner and it has 1.3 million miles? At what point in time with this product do you get more aggressive with inspection and/or replacement. (ARM would like SKF's response to this question)
- When NHTSA asked ARM if this is a future trend (unitized wheel ends), ARM responded by saying based on market acceptance, they believed this product will create a technology shift.

OEM - Issues

- NHTSA asked if there are any abnormal customer distributions - failure rates. Chuck Smith informed them that Freightliner had a rate of "Highly Progressed Incidents" that is significantly higher than other OEM's. Chuck was to debrief Tim Blubaugh of Freightliner today.

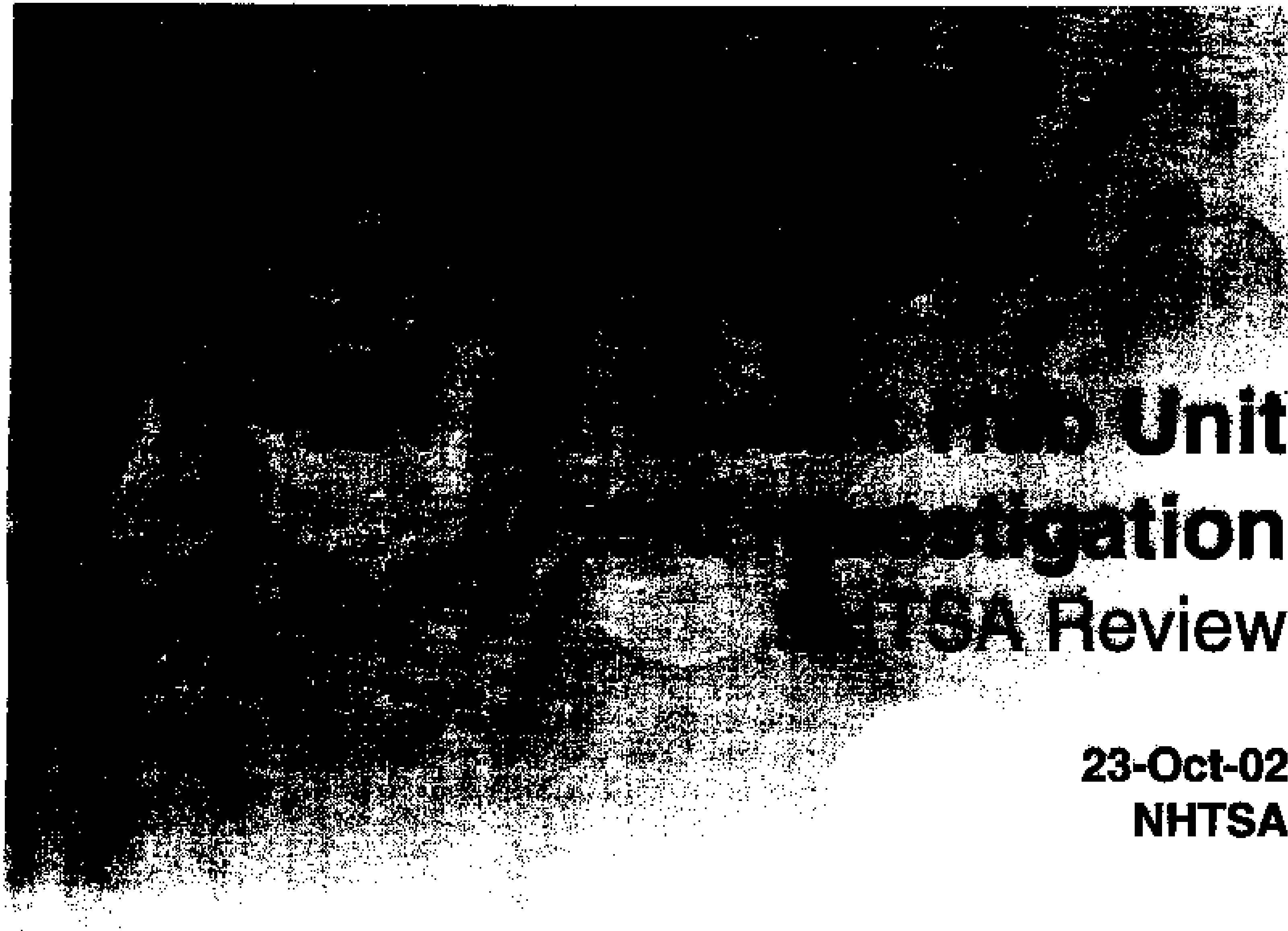
Follow-up

- No new meetings are scheduled with NHTSA, however, they have asked Chuck for the following information:
  1. A list of Wheel offs and fires
  2. Customer Sales, VINs and MIS return information

Chuck's general comments:

1. ARM is still awaiting root cause(s) and corrective actions. They are unhappy with our progress in the last 8 weeks.
2. Need the cause and corrective action to convince themselves and Freightliner that the problem has been permanently eliminated (helpful in dealing with NHTSA as well). Today, ARM does not feel that they can go to the original 200,000 mile inspection intervals (required for the acceptability of the product in the market) until the root causes are addressed.
3. Chuck has now visited "our competitors who make similar products" and stated that he is not impressed with either Aiken's equipment or processes.
4. Chuck supports a targeted field action on high incident production dates (Brad Arnold does not support this - Brad believes that inspection procedures should be enough to contain any safety concerns.)
5. ARM has several parts that they are collecting to have "third party analysis" (retired Timken people) done on them - they intend to have full dimensional layouts, etc.
6. Brad has asked his group if they think they should demand that their products be produced in Luechow (since Luechow makes better product than Aiken).

NHTSA.ppt



...Unit ...stigation ...TSA Review

23-Oct-02
NHTSA

SKF 001240

ArvinMeritor

Agenda

- Introductions
- Product Background
- Product Description
- Product Performance History Summary
- Initial Problem Investigation
- Truck Hub Unit End of Life Description
- Initial Problem Investigation (continued)
- Initial Problem Investigation Results
- Field Investigation, Phase 1
- Electronic Inspection Device In Use
- Field Investigation, Phase 2
- Next Steps
- THU Predictive Inspection Kit

Product Background

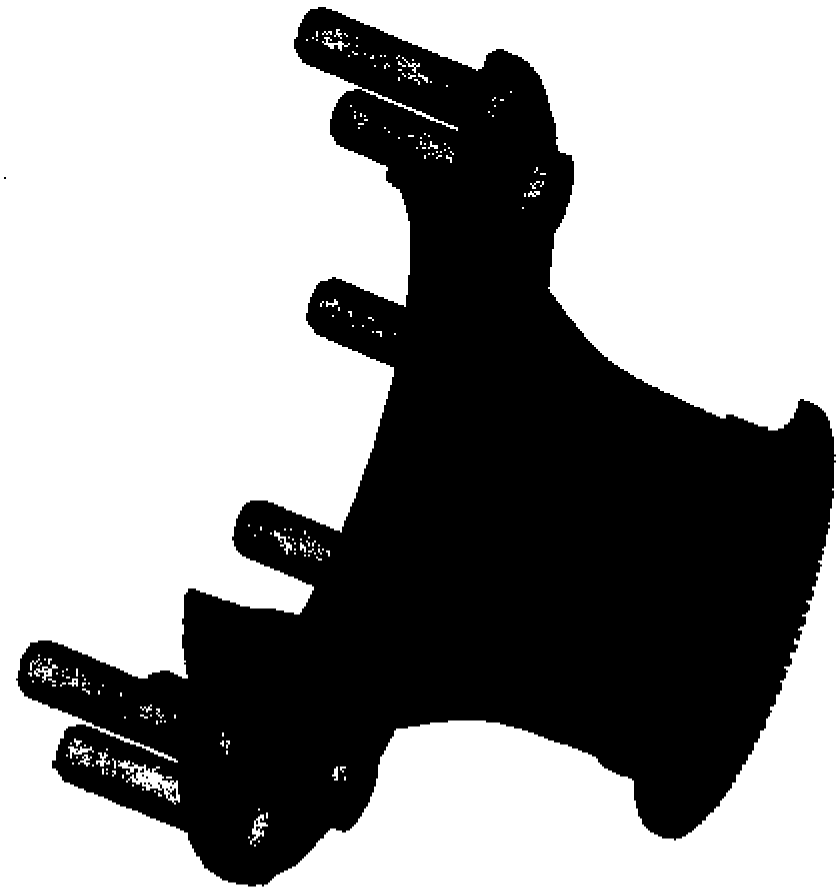
- History
  - Industry Wheel End (THU) Experience ("The Great Wheel Bearing Debate," Commercial Carrier Journal, 2/97, Pg. 49, Paragraph 1) – per NTSB, 750 to 1050 standard wheel end separations per year.
  - Unitized wheel ends (THU) successfully in use in Europe since late 1980's
- Design Criteria
  - Objectives
    - Robust fastening design
    - Sealed, no maintenance, periodic inspection only
    - Warranted for 750,000 miles
  - Application – 12 to 13.2K Line-haul
- Product Introduction
  - 1996
  - Truck Hub Unit produced in Germany, 1996 to beginning of 1999
  - Campaign for flange fracture, all of 1996 vintage replaced
  - Wheel saver campaign (improper field application)
  - Transition to US based production during 1998

Product Description

Hub Sub-System

Consists of:

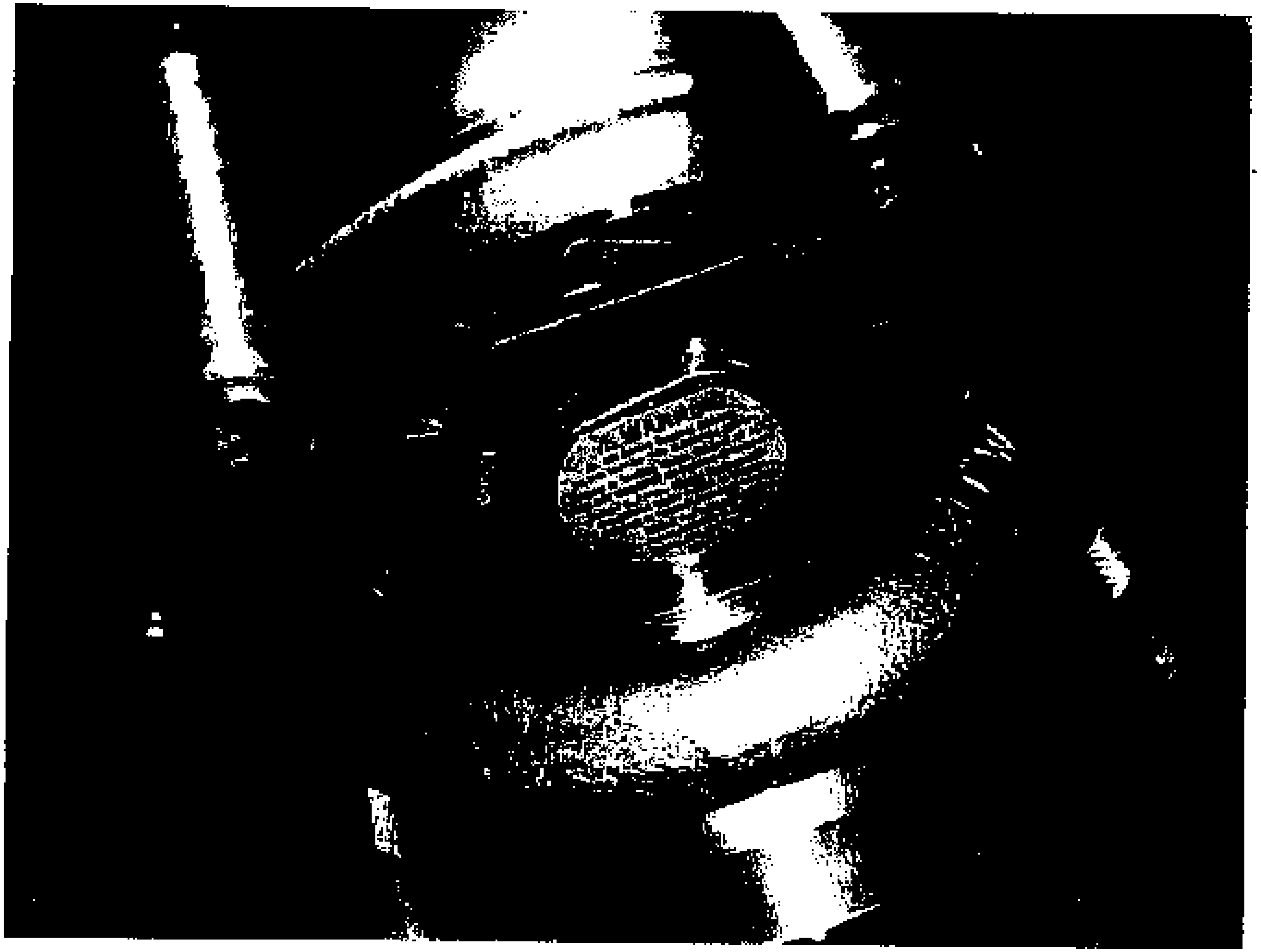
- Bearing Geometry
- Sealed for Life
- Long Life Grease
- No Maintenance, Periodic inspection only



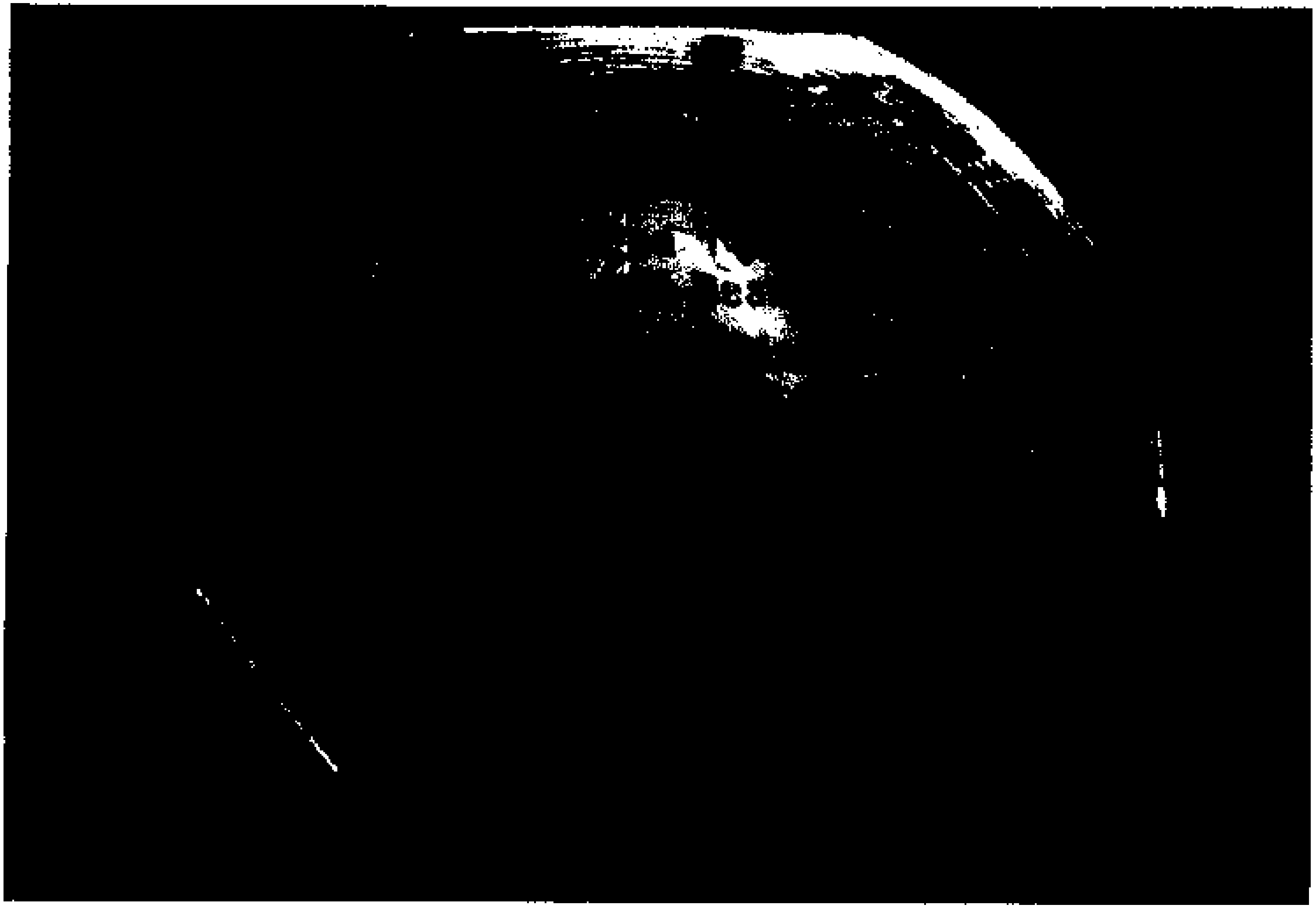
Product Description (continued)

- Robust Fastening System (objective – keep wheel on truck)
  - Large inner "D" Washer and Nut
  - Lock Washer and Outer Nut
  - Tamper Identification
  - Warning Label (proper torque, toll-free number for maintenance information, etc.)
- Product designed to operate in preload
  - New logic as compared to standard wheel end
- Sealed Hub Cap
- Inspection Instructions

Fastening and Tamper ID System



Warning Label - Maintenance



Product Performance History Summary

- Germany production has met expectations
- Product well received in the industry
- United States production issue surfaced during 2000.
  - Problem appeared discrete and contained
- Additional issue surfaced at end 2001
  - Again, problem appeared discrete and contained
  - As a contingency, design investigations and confirmations were undertaken. No significant issues found, only technology upgrade opportunities.
- By Spring 2002, it was apparent that an unidentified issue was in progress
  - Field issues included:
    - Product early wear out
    - Near wheel offs
    - Wheel offs
    - Thermal events

Initial Problem Investigation

- Categorization of problem
  - Retrieve all distressed hubs through warranty system
  - Majority of hubs analyzed for failure reason
  - Symptoms noted (representative list)
    - Oil separation from grease
    - Insufficient preload
    - Water ingress
  - Many root cause theories for the early wear out postulated
    - Inboard seal performance
    - Bearing manufacturing variation
    - Oil separation from grease
    - Numerous others
  - Questions whether wheel offs and thermal events were unpredictable, instantaneous events or were avoidable

Truck Hub Unit End of Life Description

- Path One: Follow recommended Inspection Criteria
  - Vehicle preventive maintenance cycle occurs
  - Truck front end placed on jack stands
  - End play check – if above 0.006", replace Truck Hub Unit
  - Tire rotation check for noise – if vibration or noise is detected, replace Truck Hub Unit
- Path Two: Do Not Inspect
  - Bearing distress progresses towards failure
  - Internal distress causes heat generation – Vibration during braking and turning
  - Wear progression causes increased wheel end play and activation of ABS fault signal
  - Grease and seal failure – Vibration, noise and smoke (Driver halts vehicle or continues)
  - Rollers eject; steering wheel pull, vibration, noise and horsepower increase required (Driver halts vehicle or continues)
  - Brake linings become "bearing" system – above signs + brake smell (Driver halts vehicle or continues)
  - Heat generation; visible distress signs of smoke and sparks (up to 1600 degrees F)
  - Driver stops - possible fire, or driver continues
  - Fastening system plastically deforms; wheel off, driver stops vehicle

Initial Problem Investigation (continued)

- Actions
  - Manufacturing investigation
    - Axle assembly processes and practices
    - Bearing and wheel end assembly processes and practices
  - Test track test to failure studies initiated
  - Clarity of recommended inspection process improved
  - Field communications to OEM's, Fleets, Owner-Operators
    - Manufacturing issue
    - Introduction to TP-0251
    - Issuance of TP-0298

Initial Problem Investigation Results

- Axle Assembly
  - Minor process changes and modifications incorporated
  - Hub end-play containment instituted
- Bearing and Truck Hub Unit manufacture and assembly
  - Issues leading to early wear-out identified
  - Corrections, both permanent and temporary, instituted
  - End of line containment for effectiveness confirmation instituted
- Test Track Test to Failure Status
  - Highly accelerated test completed; warning signals present
  - First full test just completed, final report and conclusions due 10/28/02
    - Preliminary indications are that warning signals are present
  - Second and third test still in progress
- Issuance of detailed, clear and field-tested inspection method (TP-0251)
  - Progressive events reduced but not eliminated
- Field communications to OEM's, Fleets, and Owner-Operators regarding inspection importance and method, as per above.
- ARM/SKF jointly developed electronic bearing failure detection device
- Initial investigation did not answer why progressive events were occurring, as detection of emerging bearing issue is detectable with TP-0251 inspection method

Field Investigation, Phase 1

- Field Investigation Structured, with following objectives:
  - Characterize field population with statistically valid sample
  - Validate effectiveness of TP-0251
  - Verify and validate electronic detection tool and method; choose best option
  - Find answer to why progressive events were still occurring
  - One fleet with multiple locations (7) and in service dates chosen (1997 to 2001).
- Results
  - Electronic detection method chosen and validated; hurdle value established
  - Effectiveness of TP-0251 confirmed (however not as sensitive as the electronics)
  - Field population characterization confirmed TP-0251, but results indicated that the special cause of progressive events was not uncovered.
  - Phase 1 completed on 366 trucks at one fleet, with results suggesting that inspection practices needed to be investigated. Consequently, Phase 2 investigation was conducted at other fleets.

Electronic Inspection Device in Use

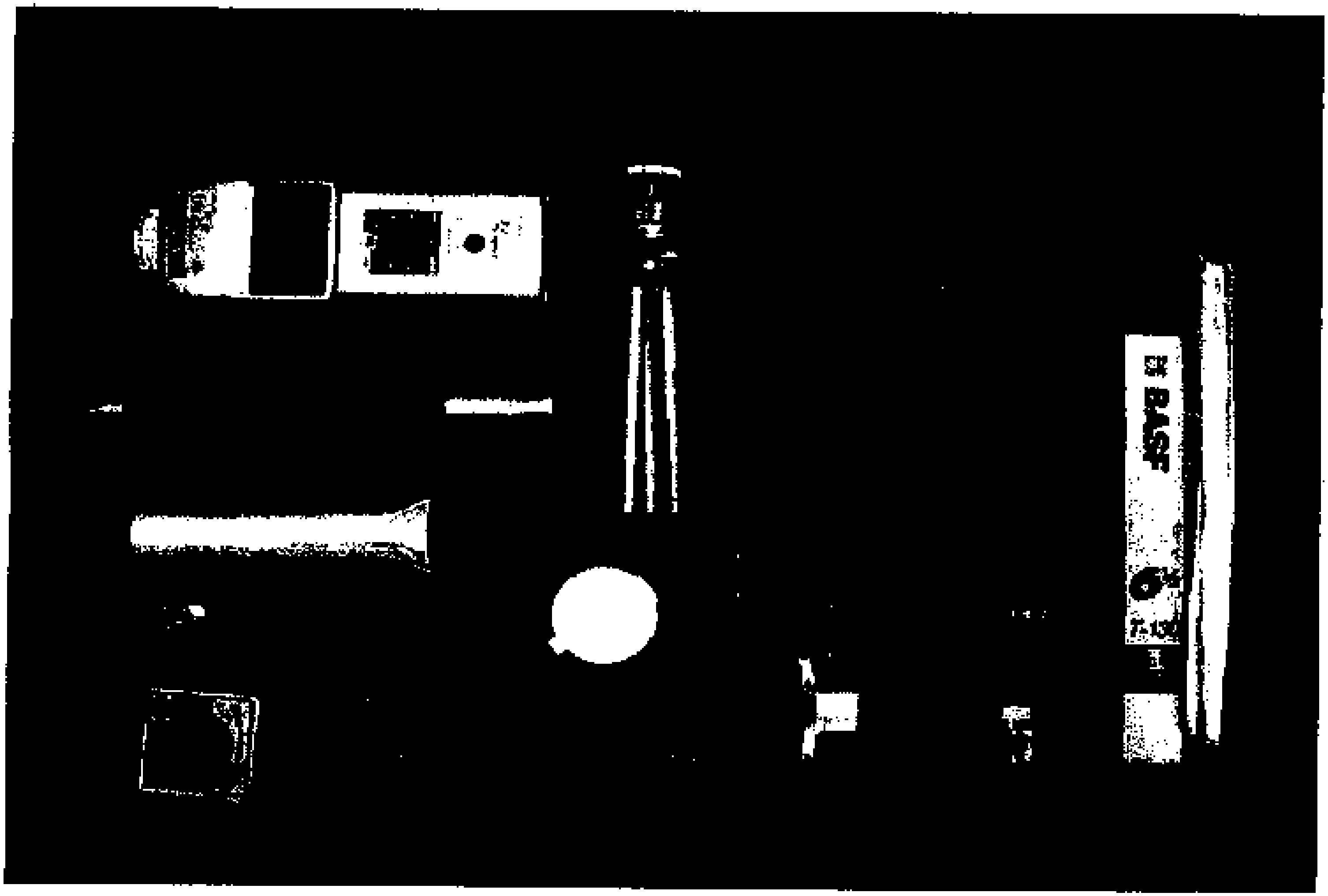
Field Investigation, Phase 2

- Phase 2 investigation structure (scope)
  - Final test of electronics threshold and use instructions
  - Evaluate multiple maintenance and inspection practices (5 locations) – BOB's, average, WOW's (Shainin Statistical Problem Solving Terminology)
  - Specifically target locations with continuing progressive events (definition of WOW)
- Results
  - Those fleets and dealerships that practice TP-0251 do not have significant events
    - No electronic device readings higher than 4.70, which is marginally detectable with TP-0251
    - On-site observation uncovered tools, knowledge and documentation compliance
    - Lack of progressive events after issuance of TP-0251
  - Those fleets/dealerships that do not practice TP-0251 have progressive events
    - Numerous electronic device readings above 11, which is highly detectable with TP-0251
    - On-site observation found lack of tools, knowledge and documentation
    - Concentration of progressive events after issuance of TP-0251

Next Steps

- Final refinement of TP-0251
- Issuance of new Technical Publication for use with electronic detection device for those users that wish to use a predictive inspection tool
- Electronic detection kit availability
- Communications: (May or may not include training)
    - OEM's
    - Fleets
    - Drivers
    - Dealerships (if OEM desires)
    - Owner-operators
    - Maintenance groups (OEM dealerships, fleets, independents)
    - Publications
    - TMC
    - ArvinMeritor/SKF District Service Managers
        - Common purpose is to elevate the awareness of the importance of inspection requirements and methods for end of life determination for this product

THU Predictive Inspection Kit



Discussion

Subject: **Reports Already Given to ARM as of 22 Oct 2002**

Category: Information

Bruce Weeks
10/22/2002 02:24 PM

To: Arno Stubenrauch/SCH/SKF@SKF, Achim Mueller/SCH/SKF@SKF, Michael D Lewis/DET/SKF@SKF, Robert J Bondy/DET/SKF@SKF

cc:

Subject: ACTION: List of THU Database Documents Already Given to ARM

Gentlemen,

Here is a list of documents I am already sure ARM has been given.

Already given to Chuck Smith at ARM on 07/25/02 (detailed on ARM database under the heading "Reports handed out to Chuck Smith":

07/25/02 Inner ring hardness (incoming inspection) (Juergen Schultheis)
07/25/02 Internal geometry - Aiken 98 - 2002 (Juergen Schultheis)
07/25/02 Gage R&R for axial clearance 1998-2002 (Juergen Schultheis)
07/25/02 Monson axial clearance report (Juergen Schultheis)
07/25/02 Missing Marking 7D
07/25/02 Inboard R-Safe Seal cleaning of stock in Aiken (due to seal defect discover) (Juergen Schultheis)
07/25/02 THU Process Layout (Juergen Schultheis)
07/25/02 MPR 100% Summary (Juergen Schultheis)
07/25/02 Procedure for checking diamond Rolls (Juergen Schultheis)
07/25/02 Component Traceability System (Implemented 01 Aug 02) (Juergen Schultheis)
07/22/02 Apex point for THU application (Juergen Schultheis)
07/22/02 Axial Clearance Procedures (Juergen Schultheis)

Already given to Dale Bell (& Chuck Smith?) at ARM on 01 Aug 2002:

Schweinfurt 166/02 Outer ring spalling
ERC NL02T903e General Visual Observations
ERC ST02T206 Visual Inspection
ERC NL02M904e X-Ray Diffraction Analysis
ERC NL02M902 Analysis of Remaining Grease
ERC NL02M903e SEM Evaluation
ERC NL02M903e Suppliment - Bore Corrosion Products Analysis
ERC NL02M9THUe Summary of Findings
Schweinfurt ST02T210 Raceway Qualification Tests (water in bearings)
Schweinfurt ST02T205 Air Leak Tests (aluminum hubcap & spindle)
NATC (no number) dated 08 Aug 2002 (delivered later) Air Leak Test (plastic hubcap & oversize threads)
E-mail from Achim Mueller concerning "Jet Cleaning of THU"

Orpheus calculations on spindle deflection by A.R.J. Reininga and G.J.Dop

Already given to Dale Bell & Chuck Smith on 12-13 Aug 2002:

Schweinfurt ST02T207 Non-Rotation During Assembly
Schweinfurt ST02T211 Stud Replacement by Hammering Out Studs
Schweinfurt ST02T209 Raceway Qualification Test of Damaged Raceways
Schweinfurt ST02T212 Static Water Splash Tests
Schweinfurt Executive Summary about ARM-THU-incidents A. Stubenrauch

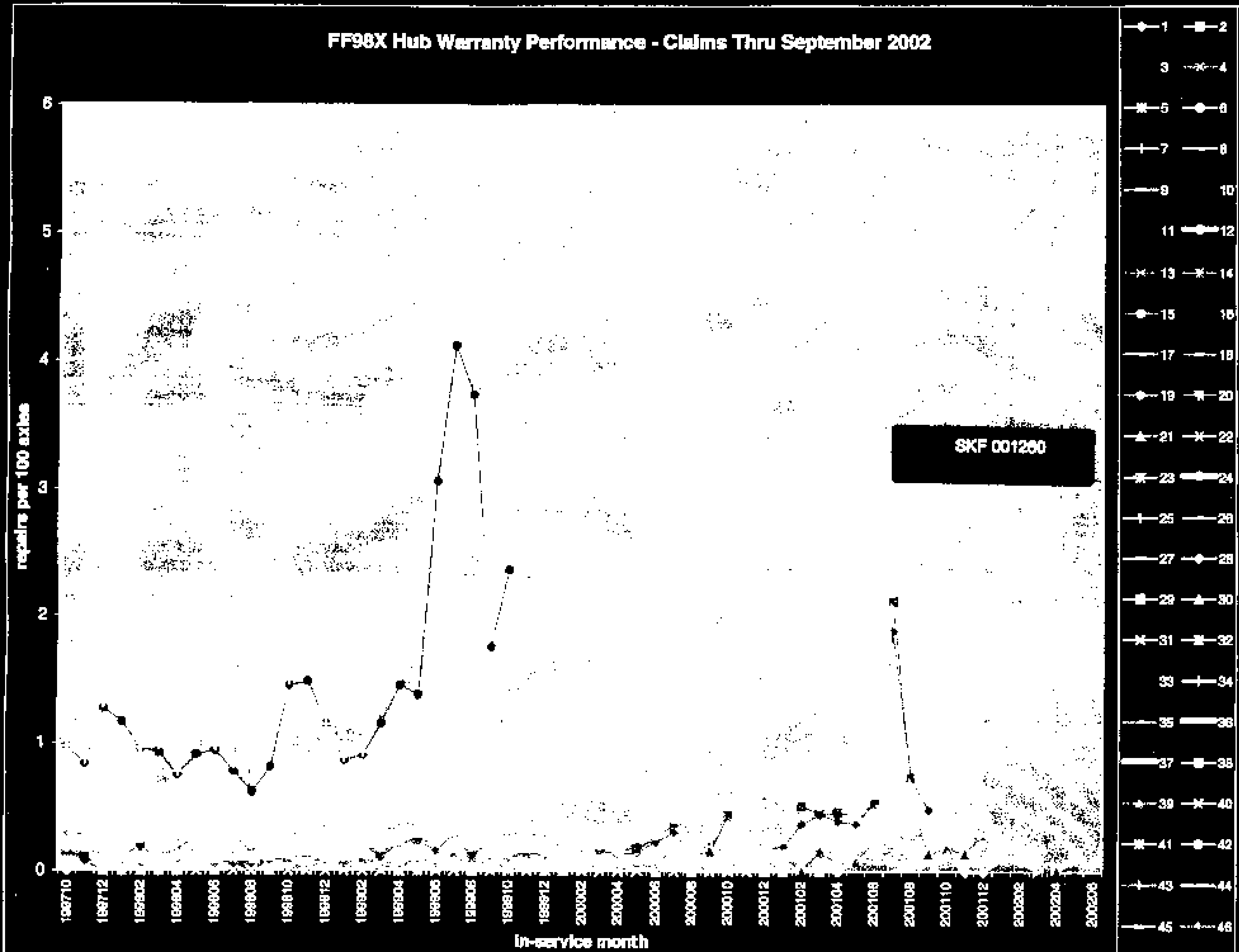
If anyone is aware of other reports that have been given to ARM, please post a response.

Discussion

Subject: Updated MIS Chart from ARM

Category: Projects, Statistics

[98x r100 sep02 data.xl


FF98X Hub Warranty Performance - Claims Thru September 2002
repairs per 100 axles
0
1
2
3
4
5
6
199710
199712
199802
199804
199806
199808
199810
199812
199902
199904
199906
199908
199910
199912
200002
200004
200006
200008
200010
200012
200102
200104
200106
200108
200110
200112
200202
200204
200206
In-service month
SKF 001260
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46

Discussion

Subject: Vibration Pen Results

Category: Quality

Field Failures15oct02, Sorts.)

SKF 001261

Field Failures
Phase 1

196	Bruno	Freightliner	1FUY3WDB1XLA30430		8/98	638409	RH	3.80	L	MJP001	None		No	JD = 19002; one tab bent only; new hub reading = 0.6
209	Bruno	Freightliner	1FUY3WDB2XLA30422		8/98	616380	RH	2.80	L	MJP002	None		No	New Hub JD = 20602, oil running out of cap rusty in appearance; New = 0.6 reading
288	GBC	Freightliner	1FUYDDYB5XLA70912		9/98	554941	RH	3.30	A	MJP003	Not Legible		No	Observed small amount of rust in seal area. New Hub reads 0.4.
321	GBC	Freightliner	1FUYDDYB2XLA70916		9/98	615800	LH	3.10	A	MJP004	24188	7/29/1998	Yes - spalled	Contaminants in Hubcap, oil running out of seal area; new hub reads 0.7;
326	GBC	Freightliner	1FUYDDYBXWLA25690		3/98	445707	RH	2.70	L	MJP005	None		No	Lots of rust on outer and inner nuts; New hub reading 0.7
331	GBC	Freightliner	1FUYDDYB1XLA70938		9/98	404255	LH	2.40	A	MJP006	Not Legible		Yes-Contamination	Oil in Hubcap and on Spindle; New hub reading 0.7
356	Croft	Freightliner	1FUYDCYB4XLA42738		7/98	378974	RH	4.40	L	MJP007	None		No	Hubcap clean and dry
474	Supervalu	Mack	1M1AA12Y7WW087167		8/97	628882	RH	2.90	L	NP4001	None		No	Greased King Pin, retorqued - still bad @ 2.9.
18	Bruno	Freightliner	1FUJACAS11LJ92606		1/01	289172	RH	2.20	A	WAS001	28700	10/13/2000	No	
15	Bruno	Freightliner	1FUJACAS61LH72212		9/00	321415	LH	4.10	A	WAS002	06701	3/28/2001	Yes - Seal Fail	No washer tabs bent; hub changed out 9/17/01, and 8/22/02 (during inspection)
262	Bruno	Freightliner	1FUJACAS51LJ92589		1/01	281875	RH	2.20	A	WAS004	28800	10/12/2000	No	No outside distress; can hear rollers with wheel and drum off; white grease at inboard "plate"; 0.8
590	Quartet	Freightliner	1FUYDDYB7YDF26467	AVF99151307	8/99	676591	RH	3.40	A	WAS005	16799	8/16/1999	Yes-Contamination	New Hub reading 0.8
405	Bruno	Freightliner	1FUJACAS21LJ92601		1/01	273301	LH	2.20	A	WAS006	29000	10/16/2000	No	Some grease on outboard seal; vibration of new hub 0.8; spindle clean with no rust
406	Bruno	Freightliner	1FUJACAS21LJ92601		1/01	273301	RH	4.70	A	WAS007	29000	10/16/2000	No	Hub difficult to remove, hot and seized to spindle; vibration 0.5
566	Quartet	Freightliner	1FUYDDYB7YDF26470	AVF99162645	6/99	586079	RH	3.80	A	WAS008	05796	3/6/1999	Yes-Contamination	Water droplets in hub cap, little rust on spindle; new hub 0.4
580	Quartet	Freightliner	1FUYDDYB4XLA70917	AVF99168495	9/99	465360	RH	2.40	A	WAS009	25598	9/12/1999	No	More than TBS of oil in Cap, grease seeping from OB seal. New hub 0.5

SKF 001282

3/11/2008

411	Knight	Freightliner	1FUYSDYB6XPA87040		8/1/1999	515464	L	0.6	L	GCB001				Replaced with a Luechow hub; hub pulled due to outer seal leak.
419	Knight	Freightliner	1FUYSDYB4YPB87393		7/1/1999	406594	L	11	A	GCB002	11599	4/26/1999	Yes	Replaced with test hub then hub from SLCReplaced with test hub then hub from SLC
420	Knight	Freightliner	1FUYSDYB4YPB87393		7/1/1999	406594	R	20.3	A	GCB003	09089	3/30/1999	Yes	Replaced with test hub then hub from SLC
402	Knight	Freightliner	1FUYSDYB4YPA87345		4/1/1999	477818	R	1.8	A	GCB004				Replaced due to oil running out of hub; no RMA
451	Knight	Freightliner	1FUYSDYB4YPA87345		4/1/1999	477818	L	4.6	A	GCB005			NTF	No RMA
439	Knight	Freightliner	1FUYSDYB9YPA87325		4/1/1999	433396	R	31.8	A	GCB006				Before brake backoff reading = 25.7; no RMA
596	Knight	Freightliner	1FUYSDYB5XPA87045		10/1/1998	592380	R	0.8	A	GCB007				Removed due to excessive oil leakage
596	Knight	Freightliner	1FUYSDYB5XPA87045		10/1/1998	592380	L	5	A	GCB008				
596	Knight	Freightliner	1FUJBBBD72PJ13201		1/1/2001	281062	L	3.2	A	GCB009				
1	CR England	Freightliner	1FUJV8CG51B94935201	AVF01008529	2/1/2001	306250	L	2.5	A	MJP008			NTF	New hub reading 1.3
11	CR England	Freightliner	1FUYSDYB7YPB35730	AVF99148364	8/1/1999	450006	L	3.3	A	MJP009	15299	6/1/1999	Yes	Oil in cap from prior hub; Tabs not bent over; King pin exhibited play. New hub 1.3
79	CR England	Freightliner	1FUJBBCG21PB38789	AVF01008017	2/1/2001	316868	L	1.8	A	No RMA, Clicker				Clicker; no o-ring, rust on spindle; new hub reading 0.4
86	CR England	Freightliner	1FUJA3BDX1PB37275	AVF99030498	5/1/2000	286151	R	1.1	A	No RMA, Clicker				Oil in hubcap; clicker; no o-ring, rust on spindle; new hub 1.6
93	CR England	Freightliner	1FUJA3BDG1PB36407	AVF00100059	6/1/2000	371311	L	1	A	No RMA, Clicker				Clicker; no o-ring, rust on spindle; new hub 0.9
108	CR England	Freightliner	1FUJA3BD41PB38633	AVF00157742	10/1/2000	275724	R	0.7	A	No RMA, Clicker				Clicker; New hub 1.4
65	CR England	Freightliner	1FUYSDYB6YPB35778	AVF99157205	8/1/1999	460851	L	0.8	A	No RMA, Clicker				Clicker; Puller to remove, no o-ring, rust on spindle; new hub 0.7
94	CR England	Freightliner	1FUJA3BDG1PB36407	AVF00100059	6/1/2000	371311	R	1.7	A	No RMA, Clicker				Clicker; no o-ring, rust on spindle; new hub 0.5
74	CR England	Freightliner	1FUJA3BD51PB38581	AVF00140142	8/1/2000	395156	R	0.9	A	No RMA, Clicker				Clicker; no o-ring, rust on spindle; new hub 0.9
87	CR England	Freightliner	1FUJBBCG91PB38790	AVF01008016	2/1/2001	307039	L	1.1	A	No RMA, Clicker				Clicker; no o-ring, spindles clean, new hub 0.9
124	CR England	Freightliner	1FUJBBCG91PB38806	AVF01008512	2/1/2001	314026	R	1.3	A	No RMA, Clicker				Clicker; New hub 1.3
82	CR England	Freightliner	1FUJBBCG31PB38798	AVF01008513	2/1/2001	213230	R	1.5	A	No RMA, Clicker				Clicker; no o-ring, spindle clean; new hub 0.5
81	CR England	Freightliner	1FUJBBCG31PB38798	AVF01008513	2/1/2001	213230	L	1.3	A	No RMA, Clicker				Clicker; no o-ring, spindle clean; new hub 0.5
88	CR England	Freightliner	1FUJBBCG91PB38790	AVF01008016	2/1/2001	307039	R	1.6	A	No RMA, Clicker				Clicker; no o-ring, spindles clean, new hub 0.4
123	CR England	Freightliner	1FUJBBCG91PB38806	AVF01008512	2/1/2001	314026	L	0.7	A	No RMA, Clicker				Clicker; New hub 0.5
109	CR England	Freightliner	1FUJA3BD01PB38578	AVF00142070	7/1/2000	315218	L	0.8	A	No RMA, Clicker				Clicker; retorqued with no change; new hub 0.3
119	CR England	Freightliner	1FUJA3BD71PB36397	AVF00100037	6/1/2000	303208	L	1.7	A	No RMA, Clicker				Clicker; New Hub 0.4
121	CR England	Freightliner	1FUJA3BDX1PB38636	AVF00160502	10/1/2000	363918	L	1.6	A	No RMA, Clicker				Clicker; New hub 0.3
631	Knight	Freightliner	1FUYSDYBXXPA87073		9/1/1999	566146	L	3.8	A	FXB001				
544	Knight	Freightliner	1FUYSDYB3XPA87044		10/1/1998	625380	R	4.8	A	FXB002				
627	Knight	Freightliner	1FUYSDYB1XPA87320		3/1/1999	496208	L	8.1	A	FXB003				Also leaking oil
736	Knight	Freightliner	1FUYSDYB01PF73723		4/1/2000	286194	R	3.8	A	FXB004				Supposedly for oil, not reading?
745	Knight	Freightliner	1FUYSDYB4XPA87036		7/1/1998	462266	R	0.7	A	FXB005				Replaced due to serious oil leak
39	CR England	Freightliner	1FUJA3BD81PB38571	AVF00143055	9/1/2000	236715	L	0.9	A	SLC001	10000	4/9/2000	NTF	Clicker; New hub 1.6
40	CR England	Freightliner	1FUJA3BD81PB38571	AVF00143055	9/1/2000	236715	R	1.4	A	SLC002	10200	4/11/2000	NTF	Clicker; New hub 1.7
30	CR England	Freightliner	1FUJA3BDX1PB38605	AVF00157748	10/1/2000	240524	R	1.4	A	SLC003	18100	5/10/2000	NTF	Hub changed for clicker; new hub 0.7; no O-ring.
33	CR England	Freightliner	1FUJBBCG81PB38858	AVF00193877	2/1/2001	192486	L	0.8	A	SLC004	31800	11/13/2000	NTF	Hub changed for clicker; New hub 1.5; No O-ring, rust on spindle
21	CR England	Freightliner	1FUJA3BD71PB38433	AVF00113439	7/1/2000	337135	L	0.6	A	SLC005	10600	4/14/2000	NTF	Hub changed, clicking; No O-ring, rust on spindle; new hub 1.4
22	CR England	Freightliner	1FUJA3BD71PB38433	AVF00113439	7/1/2000	337135	R	1.7	A	SLC006	12500	5/4/2000	NTF	Hub changed, clicking; No O-ring, rust on spindle; new hub 1.9
60	CR England	Freightliner	1FUJA3BD81PB38599	AVF00155054	10/1/2000	373486	R	1.2	A	SLC007	13000	5/9/2000	NTF	Clicker; new hub 0.9

SKF 001263

Phase 2
Failure Sort

55	CR England	Freightliner	1FUJBBCG31PB38736	AVF00193519	1/1/2001	208748	L	2.5	A	SLC008	Illegible		NTF	New hub 0.8, no O-ring
56	CR England	Freightliner	1FUJBBCG31PB38736	AVF00193519	1/1/2001	208748	R	1.6	A	SLC009	30600	11/1/2000	NTF	New hub 1.7, Needed puller for old hub
105	CR England	Freightliner	1FUJA3BD41PB38839	AVF00157742	10/1/2000	275724	L	1.4	A	SLC010	13199	5/11/1999	NTF	Clicker; hub/spindle removed, sent to Troy; new hub 1.2
110	CR England	Freightliner	1FUJA3BD01PB38578	AVF00142070	7/1/2000	315216	R	23.1	A	SLC011	15600	5/18/2000	Yes	New hub 0.5, lots of information in verbatim
115	CR England	Freightliner	1FUYSDZB01PB37243	AVF00060882	4/1/2000	313710	R	12.3	A	SLC012	25099	9/7/1999	Yes	Clicker, New hub 0.4
132	CR England	Freightliner	1FUJA3BD51PB38857	AVF00147054	9/1/2000	353157	R	3.9	A	SLC013	09700	3/8/2000	NTF	Clicking also; New hub 0.5
140	CR England	Freightliner	1FUJBBCG93PJ47621	AVF02039857	4/1/2002	53597	R	1.2	A	SLC014	24101	7/29/2001	NTF	Clicker; o-ring present, spindle clean; new hub reading = 0.9
178	CR England	Freightliner	1FUYSDZB71PB36750	AVF00063281	4/1/2000	340220	R	17.8	A	SLC015	25199	9/8/1999	Yes	New Hub 0.9, end play was 5 in/20 out
499	CR England	Freightliner	1FUJBBCG61PJ47489	AVF01026137	3/1/2001	181419	R	24.5	A	SLC016				Had to pull knuckle also
656	CR England	Freightliner				0	R	17.3	A	SLC017				True zero torque
731	CR England	Freightliner	1FUYSDZB71PB37224	AVF00054424	4/1/2000	383669	L	5.2	A	SLC018			Yes	New hub reading 0.0

SKF 001264

Discussion
Main topic:
Robert J Bondy/[illegible]
09/23 11:[illegible] AM

Subject: Prime Burn-Up Photo's

Category: Information

What: Truck fire that could be related to the bearing
When: approx - Sept 16 - 21
Who: Owner Operator (OO) vehicle working for Prime

Charles.Smith@ArvinMeritor.com on 09/23/2002 05:41:45 AM

To: Robert.J.Bondy@skf.com
cc:
Subject: FW: Prime Hub Fire

As you requested.

```
>  -----Original Message-----
> From:              Rosenthal, Robert
> Sent:              Wednesday, September 18, 2002 10:56 PM
> To:        Sanko, Thomas; Bell, Dale
> Cc:        Mejaly, Joseph; Pan, J; Smith, Charles
> Subject:           Prime Hub Fire
>
> Attached are photos of recent fire.
> We need to determine a way to reach the O.O.
>
>  <<side view.JPG>>  <<Front view.JPG>>  <<Hub Bearing.JPG>>
>
> Rosey
>
```

****

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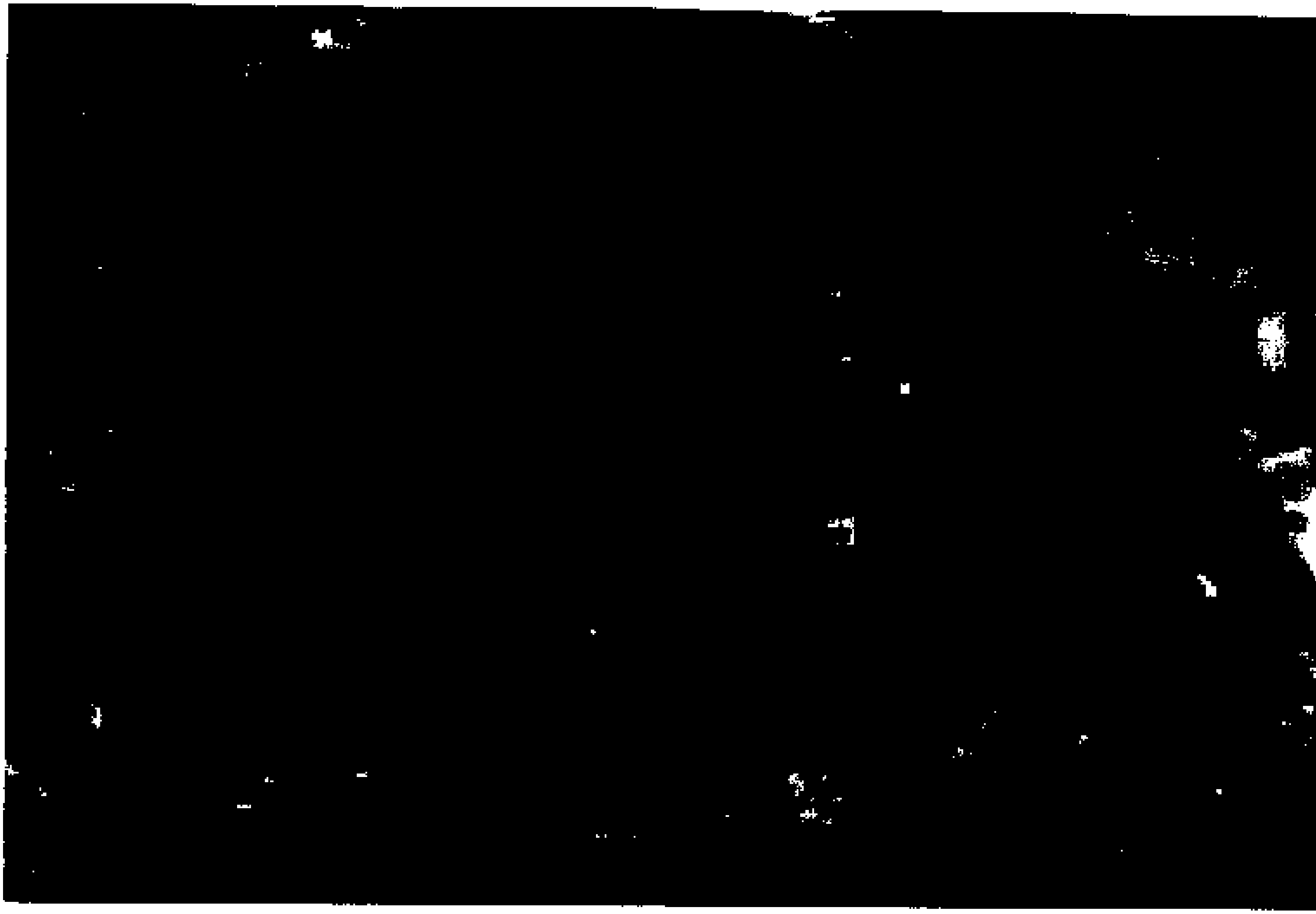
****

side view.JPG Front view.JPG Hub Bearing.JPG

SKF 001266



Discussion

Subject: **Action List Aiken / 08 - 2002**

Category: Quality

Action List Aiken attached from Action Date Base of Automotive Division:

SKF 001269

Discussion

[illegible]

Schu[illegible]

0[illegible] 12:4[illegible]

Subject: **Possible numbers of units delivered to AM with exceeded ACL values (diaphragm problem)**

Category: Quality

With the help of graphs we can clearly show that in Aiken there were time periods with diaphragm probleme.
See example:

Diaphragmproblem.pp

We made calculations for the different time periods in that way.

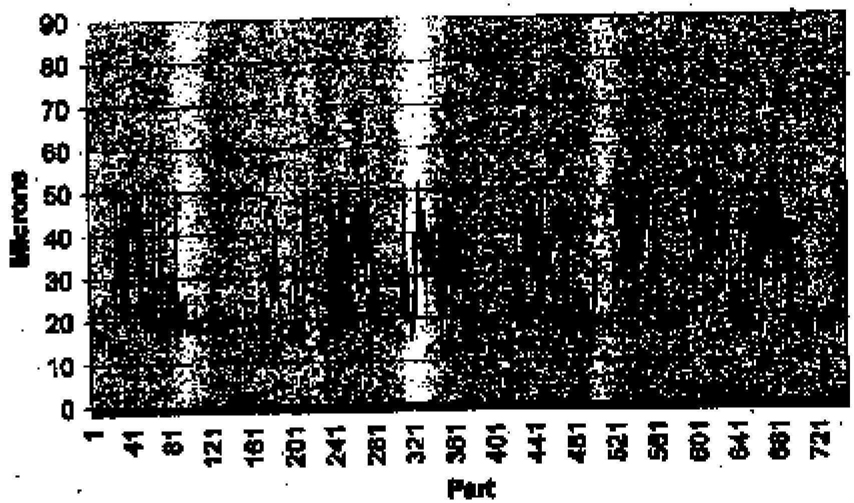
Assumption is that during period of time with diaphragm problem the ACL unit coul only measure low values of ACL.
The high values could not be measured due to air loss in diaphragm.
We assume that quality produced before diaphragm problem is the same as during period with diaphragm problem.
Reason: ACL unit delivered only good values, operator has had no reason to make re-adjustments.

So we assume that the rate of units outside upper specification before diaphragm problem and period with diaphragm problem is
compareable.
For the perod of timer before diaphragm problem we investigated the bad part list of 3 days before and after diaphragm problem
and calculated the number of units outside specification and the ACL values as well.

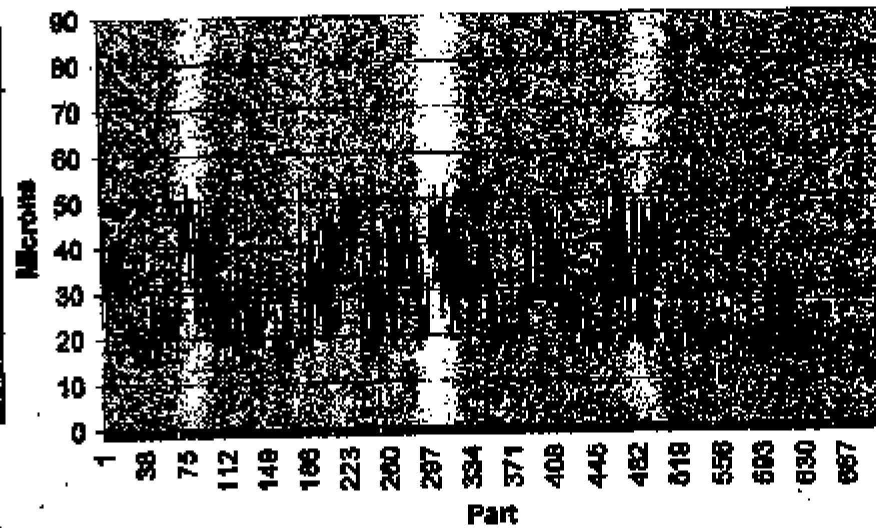
The percentage rate of units outside spec and the ACL classes as well we multiplied with the number of produced bearings
prod. during diaphragm problem.
So we came to the figures below attached in calculation sheet.

ACL_Investigation_Model 2.x

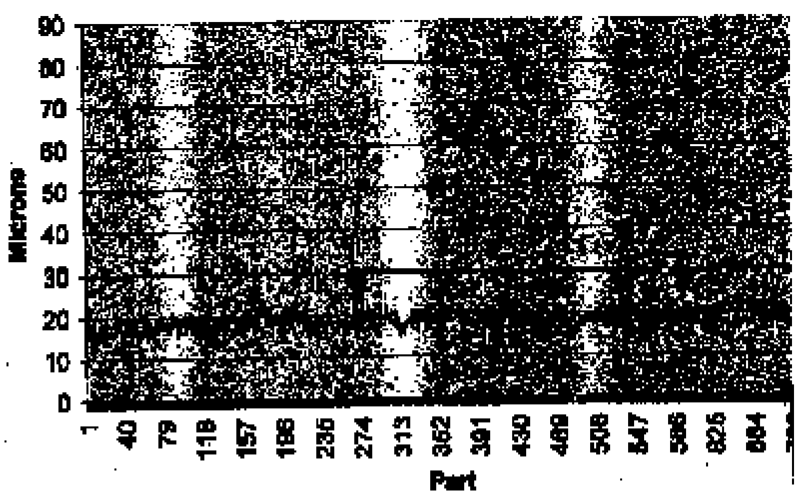
Axial Clearance 4-29-99



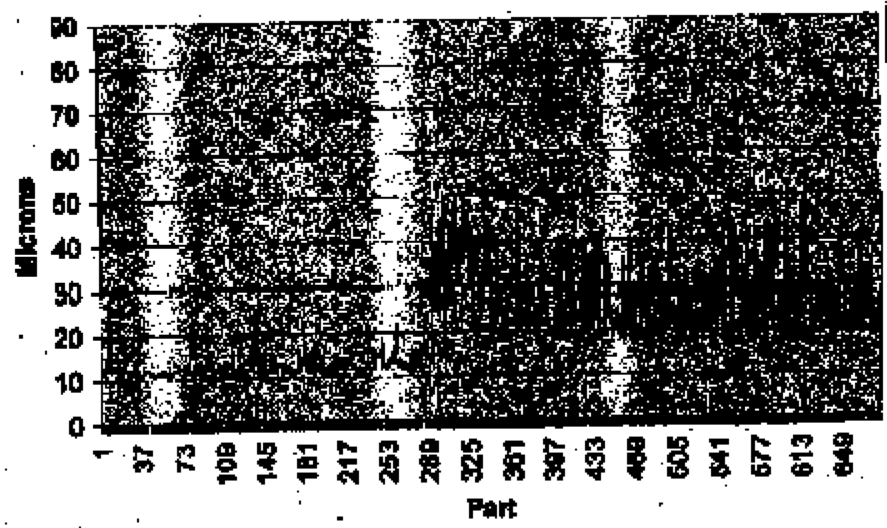
Axial Clearance 4-30-99



Axial Clearance 5-10-99



Axial Clearance 5-12-99



Axial Clearance investigation 28.04.99 <-> 17.5.99

J.S / 30.08.02

Production date:	5/13/1999	5/14/1999	5/17/1999	Sum:		4/28/1999	4/29/1999	4/30/1999	Sum:		Total - number	Total - %	Production date:
Manuf. parts:	837	793	377	2007	100%	856	817	758	2431	100%	4438	100%	Manuf. parts:
Good parts:	753	672	319	1744		760	748	701	2209		3953		Good parts:
Bad Sum:	84	121	58	263		96	69	57	222		485		Bad Sum:
Bad ACL:	4	6	18	28	1.40	1	2	6	9	0.37	37	0.83	Bad ACL:
ACL classes:													ACL classes:
50-60	1	2	9	12	0.60	1	1	3	5	0.21	17	0.38	50-60
60-70		1	2	3	0.15						3	0.07	60-70
70-80	1	1	4	6	0.30			1	1	0.04	7	0.16	70-80
80-90			1	1	0.05			1	1	0.04	2	0.05	80-90
90-100			1	1	0.05			1	1	0.04	2	0.05	90-100
100-110			1	1	0.05		1		1	0.04	2	0.05	100-110
110-120													110-120
120-130													120-130
130-140	1			1	0.05						1	0.02	130-140
140-150	1	1		2	0.10						2	0.05	140-150
150-160													150-160
160-170													160-170
170-180													170-180
180-190		1		1	0.05						1	0.02	180-190
				Sum:	1.40				Sum:	0.37	Sum:	0.83	

SKF 001274

Axial Clearance Investigation 28.04.99 <--> 17.5.99

J.S / 30.09.02

Number of manufactured units (good parts only) during diaphrame problem period.			average rate of units outside specification (%):	number of units outside specification per ACL-class:	Selection of worst case:		Number of units due to worst case:
					13.5 - 17.5.99	28.4 - 30.4.99	
Manuf. Units:		Bad ACL (total):	0.83	49	1.40	0.37	81
		ACL classes: (ym)					
2-May	5	50-60	0.38	22	0.60	0.21	35
3-May	604	60-70	0.07	4	0.15		9
4-May	764	70-80	0.16	9	0.30	0.04	17
5-May	922	80-90	0.05	3	0.05	0.04	3
6-May	835	90-100	0.05	3	0.05	0.04	3
7-May	526	100-110	0.05	3	0.05	0.04	3
8-May	0	110-120		0			
9-May	14	120-130		0			
10-May	724	130-140	0.02	1	0.05		3
11-May	764	140-150	0.05	3	0.10		6
12-May	681	150-160		0			
		160-170		0			
		170-180		0			
Total:	5,839	180-190	0.02	1	0.05		3

Axial Clearance Investigation 05.01.99 <-> 16.01.99

J.S / 31.08.02

Production date:	1/5/1999	1/6/1999	1/7/1999	Sum:		1/14/1999	1/15/1999	1/16/1999	Sum:		Total - number	Total - %	Production date:
Manuf. parts:	707	738	730	2175	100%	793	738	418	1949	100%	4124	100%	Manuf. parts:
Good parts:	501	536	585	1622		657	576	355	1588		3210		Good parts:
Bad Sum:	206	202	145	553		136	162	63	361		914		Bad Sum:
Bad ACL:	4	2	2	8	0.37	10	20	6	36	1.85	44	1.07	Bad ACL:
ACL classes:													ACL classes:
50-60	2	1		3	0.14	3	15	0	18	0.92	21	0.51	50-60
60-70				0	0.00	2	1	3	6	0.31	6	0.15	60-70
70-80		1		1	0.05			0	0	0.00	1	0.02	70-80
80-90				0	0.00	2		0	2	0.10	2	0.05	80-90
90-100				0	0.00	1		3	4	0.21	4	0.10	90-100
100-110				0	0.00		0		0	0.00	0	0.00	100-110
110-120			1	1	0.05	2	2		4	0.21	5	0.12	110-120
120-130			1	1	0.05						1	0.02	120-130
130-140				0	0.00						0	0.00	130-140
140-150	2			2	0.09						2	0.05	140-150
150-160											0		150-160
160-170											0		160-170
170-180											0		170-180
180-190				0	0.00		2		2	0.10	2	0.05	180-190
				Sum:	0.37				Sum:	1.85	Sum:	1.07	

SKF 001276

Axial Clearance Investigation 05.01.99 <--> 16.01.99

J.S / 31.08.02

Number of manufactured units (good parts only) during diaphrame problem period.	
Manuf. Untis:	
8-Jan	636
9-Jan	383
10-Jan	197
11-Jan	404
12-Jan	633
13-Jan	716
Total:	2,969

	average rate of units outside specificaiton (%):	number of units outside specificaiton per ACL-class:	Selection of worst case:		Number of units due to worst case:
			5.1 - 7.1 99	14.1 - 16.1.99	
Bad ACL (total):	1.07	32	0.37	1.85	55
ACL classes: (ym)					
50-60	0.51	15	0.14	0.92	27
60-70	0.15	4	0.00	0.31	9
70-80	0.02	1	0.05	0.00	1
80-90	0.05	1	0.00	0.10	3
90-100	0.10	3	0.00	0.21	6
100-110	0.00	0	0.00	0.00	
110-120	0.12	4	0.05	0.21	6
120-130	0.02	1	0.05	0	1
130-140	0.00	0	0.00	0	
140-150	0.05	1	0.09	0	3
150-160		0			
160-170		0			
170-180		0			
180-190	0.05	1	0.00	0.10	3

SKF 001277

Summary of parts delivered to customer outside ACL specification

J.S / 2.09.02

	28.4 - 17.6.99	5.1 - 16.1.99	29.6 - 19.7.99	Total:
Bad ACL (total):	81	55	97	234
ACL classes: (µm)				
50-60	35	27	49	111
60-70	9	9	16	34
70-80	17	1	2	21
80-90	3	3	5	11
90-100	3	6	11	20
100-110	3			3
110-120		6	11	17
120-130		1	2	4
130-140	3			3
140-150	6	3	5	13
150-160				0
160-170				0
170-180				0
180-190	3	3	5	11

No. of produced units:	5,839	2,969	5,272	14,080

Discussion

Subject: Protocol about axial clearance test measurements at Aiken 13 - 15th August

Category:

ARM end play returns.xl

Subject: **Agreed Actions at Aiken August 15 2002**

Category: Quality

Please find attached the action plan produced and agreed with the Aiken team

THU actions in Aiken.doc

SKF 001281

Action Plan for the THU channel in Aiken

August 15, 2002

Team: Ed Cotter, Chris Jones, Arno Stubenrauch, Bill Farrel, Mario Winkler, Mike May, George Wireman, Bernd Stephan, Claes Rehmberg

1. Prepare the ARM audit in Aiken CJ and JS

- J. Schultheis to support in Aiken (approx 2 weeks) and participate to the audit BS/CR (Aug 19)
    - We should propose an audit/visit date in early September to ARM. (BF)
- Focus:
    - axial clearance gauge + data (max, min, Cpk) see also point 5
    - scrap rates and reasons (per day)
    - prepare channel for "Scrap without compromise / green flow"

2. Channel

- Analyse the gage for software, electronic + hardware failures and potential design problems of equipment Aiken Team (start Aug 15)
- Improve the inner ring profile plus surface quality Aug 15
- Diamond roller from Luechow. (Aug 19)

Short Term: (immediate implementation)

- Visual inspection after honing process for the OR. CJ (Aug 19)
- Independent inspectors in the channel (one per shift) EC/CJ (Aug 19)

(Could we get one from Luechow, who knows the process ?) BS

Long Term:

- Possibly invest in combined 100% noise and axial clearance equipment from QTC (equipment feasibility to be checked Monday) CJ (Aug 19)

3. Report of results of the 6 rejected parts from ARM and improvement actions CJ (Aug 15)

4. Prepare new master parts and measure them in Luechow BS (Aug 19)

5. Specific events on April 20 and May 3 1999

- Axial clearance readings these dates, plus days before and after. CJ (Aug 15)
- Readings from feb 1999 (after the first diaphragm replacement) CJ (Aug 15)
- Readings from all days 2002. CJ (Aug 15)
- Readings from full 1998, 1999, 2000, 2001. CJ (Aug 20)
- Logbook events on the 2 dates. CJ (Aug 15)

6. Differences between Luechow and Aiken

- Design. ML
- Grease fill of the seals from CFW. Letter was send from Luechow to Aiken July 27 1998. (to Kevin Lechene)
- Process JS

7. Check if the trailer THU shows the same problem CJ (Aug 19)

SKF 001282

8. Split warranty data between Luechow and Aiken. BW (Aug 20)

9. Communication improvement between Aiken, NATC/Sales and BUT (Ge)
- Regular meetings to be fixed (video conf). Start with weekly meetings between Aiken and NATC/Sales. Later monthly meeting could do. Monday mornings BF / EC / AM and/or AS (Aug 19)
MMR to be exchanged (both ways). (Immediate.)

Discussion

Arne

Subject: **Agreed Actions at Aiken on 2002-06-18**

Category:

Please see the report from Claes Rehmberg about these points

SKF 001284

Discussion

Subject: **Reports handed out to Chuck Smith (25-07-02)**

Category: Quality

There was a meeting on 25-07-2002 at NATC in Detroit with Chuck Smith (Q-director Arvin Meritor)

During that meeting following documents/reports were handed out to Chuck Smith (copy Bob Bondy)

Subject 1: Axial Clearance

Differences in manufacturing and measuring of axial clearance within the channel:

Axialclear_Lue_Aiken.do

Procedure for setting/calibration of axial clearance measuring equipment installed in THU channel Aiken:

axialclear_routine_aiken.do

Results of R&R-studies for axial clearance measuring equipment installed in THU channel Aiken:

R&R_axialclearance98.pc R&R_axialclearance99.pc R&R_axialclearance00.pc R&R_axialclearance01.pc

R&R_axialclearance02.pc

Subject 2: 8D-report for THU's with exceeded axial clearance (Monson Case):

Monson_Report_AxialClearance.d

Subject 3: 7 Step Report - Missing marking

7_Stepreport_Missingmarking.d

Subject 4: 7 Step Report - Seals

__ 7_Stepreport_Seals.do

Subject 5: Process Flow of THU Channel Aiken / Measuring equipment

THU_ Process Layout Aiken .x

MPR_100%_summary.dc

Subject 6: Product Audit July 2002:

ProductAudit_072002.doc

Subject 7: Internal Geometry 1999 --> 2002:

1998 figures were not available. Lost during organisation change.

Monthly Internal Geometry Results98-02

Due to missing 1998 figures the advantages of diamont dressing rollers were explained as well as the
procedure for the ordering and checking of diamont dressing roller was shown:

schulthels2002-08-09_133451.j

Subject 8: Component Traceability System (Implemented 1, August 02)

Samples:

Traceability.doc

Subject 9: Inner ring hardness validation (history)

IR_hardness_98-2000.xl

Subject 10: APEX comparison Luechow - Aiken

apex_point.doc

Differences in manufacturing / matching the specified axial clearance between SKF Aiken and SKF Luechow:

SKF Aiken:	SKF Luechow:
IR raceway diameter grinding according to defined tolerances	OR raceway diameter grinding according to defined tolerances
Stand out measuring of cone set (2 cones) after assembly of rollers and cages by measuring automatics	100% OR raceway diameter measuring by automatics
Stand out result of cone sett transferred to OR raceway grinder - raceway of OR will specifically ground for the cone set.	cones are grouped in 6 different groups (stand out)
OR and cones set will be matched	According to outer diameter the the adequate cones (stand out) are assembled automatically.
100% measuring of axial clearance by measuring automatics	100% measuring of axial clearance by measuring automatics.
According to axial clearance result unit will be sorted as "in specification" or "out of spec." "units in spec" will be transferred to next operation.	According to axial clearance result "in spec." process will continue "out of spec." process will be stopped..
"Units out of spec." will be sorted out on special rework station. Operator has to exchange cones according to actual axial clearance results.	Operator has to exchange the cones manually.
Reworked units have to pass 100% axial clearance measuring automatics again.	Re-matched units will be checked for axial clearance again. Only units "in spec." can leave the station.

Root Cause Of Manufacture:
An Axial Clearance Gage problem was noticed in January of 1999. During the initial malfunctioning of the gage, the units in which the gage classified as low axial clearance were adjusted by replacing nominal size inner rings with smaller diameters to increase the axial clearance value. This is a normal ..F practice, if there is an axial clearance rejection; inner rings are replaced accordingly to adjust ..e axial clearance to within the required specification and re-gaged. Since the axial clearance gage diaphragm was not applying the proper load and nominal inner rings were replaced with smaller ones, the combination resulted in units having excessive axial clearance values, which were classified as acceptable by the gage.

Root Cause Of Non Detection:
The gage continued to provide similar readings of clearance without a noticeable change after 25 to 30 consecutive parts were gaged. The malfunction on the gage was attributed to a failure of the diaphragm material; the diaphragm is used to provide the load in checking the axial clearance. The load is necessary in order to properly seat the inner ring bearing assemblies prior to making an axial clearance check. The proper load to be applied is 300 Newton's.

Interim Action / Containment:

Identifying the root cause was not immediate, therefore a decision was made to quarantine 2,000 bearings based on the Edmunds Axial Clearance Gage Data Base, which stores up to 5,760 consecutive readings. This quantity was chosen as being a conservative number based on the timing of the gage malfunction as determined from the recorded data. To provide full protection against any potential erroneous readings, the quarantined quantity was chosen based on all the values that were stored in the gage data file, and how they varied to one another.

..er replacing the first diaphragm, part masters were made with known values that were utilized to verify gage repeatability and provide assurance that the gage was functioning properly if problems occurred. Over a period of about nine months, two additional diaphragms were replaced. This resulted in a redesign request to Edmunds Gages and establishing a regular scheduled TPM to change the diaphragm.

The 2,000 quarantined bearings were later re-gaged utilizing a newly designed manual off-line gage. However, there were some differences between the two gages:

1) The off-line gage measured statically instead of dynamically;
2) The off-line gage did not rotate the bearing;
3) The off-line gage measured axial clearance after complete assembly of bearing (grease/seals) where as the on-line gage measured with only the inner rings installed.

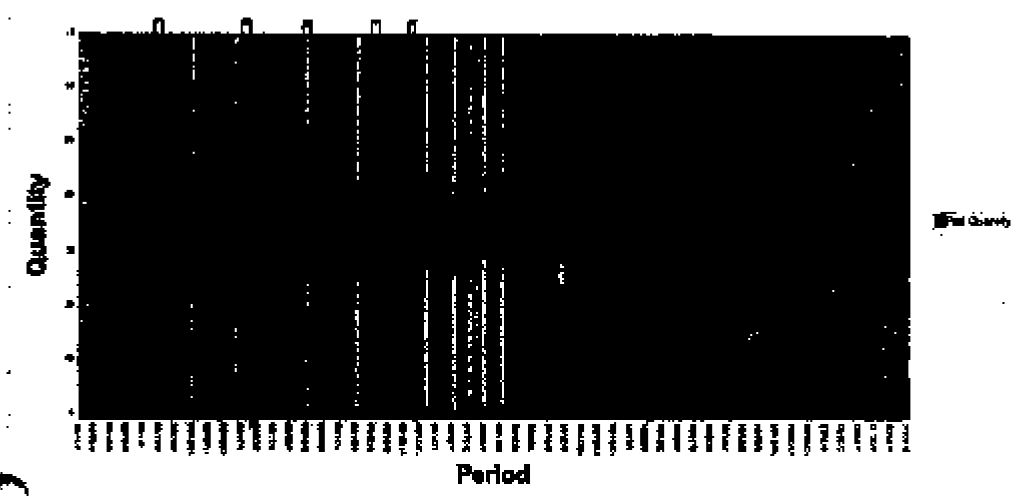
Correlation studies were conducted between the two gages, which indicated at that time that the off-line gage was capable of detecting outliers.

The shipment of the 2000 quarantined bearings was delayed for about 10 months from their manufacture due to the time required to manufacture the manual gage and perform gage R&R testing. This accounts for the wide range of in-service dates for the vehicles involved.

Further Investigation revealed additional problems and corrective actions concerning the axial Clearance gage (see following detailed list and attached chart):

- October 31, 1998 – Axial Clearance Gage air leak found
  Corrective Action – Repaired Leak (October 31, 1998)
- January 21, 1999 – Axial Clearance Gage Diaphragm failure
  Corrective Action – Replaced Diaphragm and quarantined approximately 2,000 bearings (January 21, 1999)
- May 31, 1999 - Axial Clearance Gage Diaphragm failure
  Corrective Action – Replaced Diaphragm (May 31, 1999)
- August 20, 1999 – Bearing wobbles when rotated
  Corrective Action – Axial Clearance Gage upper and lower bearings were replaced (August 20, 1999)
- **October 6, 1999 - Changed Mounting of Diaphragm to reduce wear**
- January 7, 2000 - Axial Clearance Failure
  Corrective Action – Replaced Diaphragm (January 7, 2000)
- February 29, 2000 - Axial Clearance Gage Diaphragm replaced
  Corrective Action – Replaced Diaphragm (February 29, 2000)
- **March 31, 2000 - Axial Clearance Gage retrofitted with new cylinder design replacing diaphragm.**
- April 27, 2000 –Centering Ball broke off of lower tooling
  Corrective Action – Aligned Shaft (April 27, 2000)
- **June 6, 2000 - Axial Clearance Gage upper and lower bearings were replaced**

SKF Aiken Fail Quantity based on Hub Julian Dates



Additional Interim Corrective Actions:

1. Requested Edmunds Gage for complete on site evaluation of axial clearance gage for re-design of gage to eliminate issue.

2. Replace diaphragm every three months to ensure no material failure occurred, while complete gage design was being investigated.

3. Create two hub assemblies to be used as masters and verify the on-line gage repeatability on a regular basis.

Corrective Actions:

1. Redesign gage and fabricate parts by Edmunds Gage.
   Completion Date: February 2000.

2. Retrofit gage with new special cylinder.
   Completion Date: March 2000.

3. Implement three masters to perform validation checks at the beginning of each shift and chart results on form SKF THU-0034.
   Completion Date: October 2001

SKF

Automotive Division
Aiken, South Carolina
Truck Hub Unit 7

Axial Clearance Result

Month: ______________ Part Number: ____________________

Model	[illegible]		[illegible]		DAY 3		DAY 4		DAY 5		DAY 6		DAY 7		DAY 8	
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
BG35922-1																
BG35922-2																
BG35922-3																

Model	[illegible]		[illegible]		[illegible]		[illegible]		DAY 13		[illegible]		[illegible]		DAY 16	
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
BG35922-1																
BG35922-2																
BG35922-3																

Model	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		DAY 23		DAY 24	
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
BG35922-1																
BG35922-2																
BG35922-3																

Model	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		DAY 31	
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
BG35922-1														
BG35922-2														
BG35922-3														

BG35922-1 Range = .005 - .009 mm BG35922-2 Range = .040 - .045 mm 922-3 Range = .070 - .075 m

Form SKF THU-0034

The actions above have provided a consistent application of the 300 Newton load.

Current Containment Actions:

A stock audit was performed on September 20, 2001, in which five bearings from each month remaining in the warehouse (March, April, May, July, & August of 2001) were re-inspected for axial clearance. The studs, ABS rings were removed and the axial clearance was rechecked using the on-line axial clearance gage. The results were compared to the initial readings stored in the GE Fanuc Cimplicity during their original production. Remembering that these bearings were rechecked with grease and seals installed whereas the original measurements did not have these impediments, our findings indicate the rechecked results are similar to the initial measurements.

7-Step Corrective Action.

7-Step Initiator/Team Leader: Christopher Jones	Phone:(803) 663-8652	Status: Closed.
	Fax:(803) 663-8611	Issue Date:07/26/02
Supplier: SKF USA Inc.	Supplier Code: 77248	Revision Date: 07/26/02
Location: SKF Automotive / Aiken 1084 International Pl. Graniteville, SC 29829	Date of Occurrence: 06/05/02	Date Root Cause Ident. 07/20/00
Part No.& Description: BTF-0052	Date PCA Identified: 06/05/02	Date PCA Implemented. 06/05/02
Source of Complaint: ArvinMeritor	Date PCA Verified: 07/01/02	Date Closed: 07/24/02.
Line Affected: THU	N/C Ticket Number	Referral Number: AK02THU004

8D Team: Chris Jones Quality Assurance Manager, Kevin Cannon Quality Engineer, Mario Winkler Channel Manager, John Thomas Electrical Engineer.

1. **Problem Description**

Two bearings were returned to Arvin Meritor from the field for warranty analysis. During the investigation it was found that both bearings did not contain any identification marks on the side of the outer ring flange. SKF has visually examined only one of the two bearings and determined that based on the seal installed in the bearing (Freudenburg) it is a BTF 0052 and therefore manufactured before April 6 Th. 2000 when a seal change was introduced. After further investigation it was also found that bearing did not contain the pin marked number placed on the outer ring after heat treatment. This fact means the bearing was produced before March 1 St. 2000 which is when the pin marker was introduced into the channel process as a corrective action. The second bearing has not been seen and therefore not even a rough manufacturing date can be determined.

2. **Interim Action / Containment:**

Total Bearings in house are 4,166 and the number break down is as follows:

2,562 BTF-0065 A (HUFFOUTS 32)

1, 604 BTF-0065 B (HUFFOUTS 34)

*** All bearings with operations conducted outside of the normal channel flow is logged into a rework log book by serial number and this provides an excellent opportunity to verify all markings are present.
All the above bearings have been inspected for bearing marking and found to be in full conformance

7-Step Corrective Action.

3. Root Cause.

During the normal channel process the marking of the bearing on the flange outer diameter is the third operation from the final packing station. This means all turning , grinding and assembly operations are complete and in specification, the bearing is fully assembled with exception of the studs and ABS ring

After a detailed investigation it is felt that the bearings were not marked due to fault with the marking machine. The bearings continued through the remaining channel process having the studs and ABS ring fitted and passed visual inspection without the lack of marking being noticed.

Based on the results from visual inspection the below corrective action was implemented in 07/20/00, this will verify every cycle that the marking operation is complete prior to releasing the bearing to the next operation.

4. Corrective Actions:

* Implement in controller (machine logic) that an electrical feedback is given to the plc

(Programable logic controller) verifying the marking operation has been completed on every cycle.

Completion Date : 07/20/00.

* Modify channel program logic to eliminate any possibility to manually bypass the marking operation.

Completion Date . 08/0502.

* Implement daily TPM check for stencil condition for damage and ware.

Completion Date : 07/24/02.

* Update PFMEA.

Completion Date : 07/31/02.

5. Verification:

Since the channel logic has been changed a total of 4543 bearings have been produced and verified for their marking. The serial numbers of these bearings have been recorded to ensure full verification.

6. Control

The channel program logic can only altered by two trained certified engineers. no operator intervention can occur to remove the verification and bypass over rides currently installed in the system.

7. Prevention:

The measures outlined in this corrective action report will be considered permanent.

Chris Jones
Quality Assurance Manager
SKF Automotive Division
Aiken.

7-Step Corrective Action.

7-Step Initiator/Team Leader: Christopher Jones

Phone: (803) 663-8652
Fax: (803) 663-8611

Status: Closed

Supplier: SKF USA Inc

Supplier Code: 77248

Issue Date: 04/09/02

Location:
SKF Automotive / Aiken
1084 International Pl.
Graniteville, SC 29829

Date of Occurrence: 01/10/02

Date Closed: 07/18/02

Part No.& Description: BTF-0065

Source of Complaint: ArvinMeritor

N/C Ticket Number

Line Affected:
FF-981 Easy Steer non-drive front axle

Referral Number: AK02THU003

7D Team: Chris Jones - SKF Quality Assurance Manager, Mario Winkler - SKF Channel manager, Kevin Cannon SKF Quality Engineer, Mike Lewis - Manager Truck Application Engineering, Bruce Weeks - Project Manager Application Engineering, Robert Bondy - Senior National Account Manager, William J Farrell - Chicago Rawhide - Sales, Roy Cinqurgrani - Chicago Rawhide Quality Control Manager, Bill Tubbs - Chicago Rawhide Quality Analyst, David Simms - Chicago Rawhide Senior Heavy Duty Application Engineer

1. **Problem Description**

ArvinMeritor contacted NATC in Detroit to report early failures concerning BTF-0065 units. Preliminary indication was failures were related to inboard seal flaws. Failed units serial numbers, manufacture dates, and the truck mileage are listed below:

Serial No.	Manufacturing Date	Mileage
0312174	10/17/00	109,316
0328003	01/05/01.	57,613
0332652	02/27/01.	60,934
0334602	03/09/01.	91,572
0321457	11/13/00.	69,353
0348840	07/24/01	21,093

2. **Interim Action / Containment:**

1.) All of the current SV-BTFB 4463269 CD R-Safe seal stock were sent to Chicago Rawhide in Elgin, for disassembly, cleaning and sorting. In addition, parts produced in CR Bethlehem that were rejected from Aiken stock and sent to Elgin have been scrapped. These parts were not sorted and/or reshipped.

2.) PPAP and purchase seal at new location (Chicago Rawhide - Elgin). Upon approval of the new seal, sorting was discontinued and only new 100% inspected product was used to replace all seals or build new bearings.

7-Step Corrective Action.

3) Created new procedure and log book for replacing old seals with new ones, and implemented a identification plan for certified stock

(Reference following Procedure and Log Sheet)

SKF SKF Standard & Practices Automotive Division Work Instruction (WI)	THU 2.1 **BTF-0065 Steer** **SV-BTFB 446329 CD** **R-Safe Seal** **Rework Procedure**	Section WI 312.1 Page 2(2) Issue 1 Date 04/02 Compiled by klc Approved by cbj Location SKF Aiken

1.0 PURPOSE

The purpose of this procedure is to provide guidelines for the correct rework of replacing the SV-BTFB 226329 CD inboard seal and the applicable makings required after completion of rework.

2.0 SCOPE

This procedure applies to supervisors, production team members, and anyone assisting within the THU 2.1 Channel in SKF Aiken, SC.

3.0 DEFINITIONS

3.1 Nonconformance: Product or material that does not conform to the Customer requirements or specification.

3.2 Scrap: Product or material discarded because of an individual or multiple customer specification / requirement is not met.

4.0 PROCEDURE

4.1 Carefully, remove old inboard seal and scrap it.

4.2 Clean seal bore verifying no bore tight enters the grease.

4.3 Place bearing on channel for insertion of new seal and tone ring

4.4 Remove completed bearing from channel. Place "1 inch yellow dot" on back of bearing flange using paint stick and mask.

4.5 A.) If seal is a reworked (inspected) seal, apply a ¼ x ¼ "X" between the serial number and date code and on one of the machined bosses above the brake pilot diameter and record the serial number on form SKF-THU 036 to verify rework has been completed.

7-Step Corrective Action.

B.) If seal is an new seal (new mold), apply a ¼ x ¼ "Z" between the serial number and date code and on one of the machined bosses above the brake pilot diameter and record the serial number on form SKF-THU 036 to verify rework has been completed.

4.6 Visually Inspect

4.7 Pack bearing

6.0 *REFERENCES*

6.1 Qd IP 465 : Control of Nonconforming Product

THU 2.1 BTF-0065 SF-BTFB 446329 CD R-SAFE SEAL REWORK SIGN OFF CHECK SHEET

	Rework Date:

SERIAL #	**A**	**B**	**SERIAL #**	**A**	**B**	**SERIAL #**	**A**	**B**

Verification Signature:	Date:

SKF-THU 036 (04/2002)

7-Step Corrective Action.

4.) Quarantined all stock in Aiken, Stathum Warehouse, and immediate return of all stock at ArvinMeritor for the replacement of old seals.

Total Number Of Bearings Reworked - 6,367
BTF-0065A - 3,347
BTF-0065B - 3,020

Total From all Meritor Facilities - 1442
From Meritor Fletcher - 810
BTF-0065A - 648
BTF-0065B - 162

From Meritor Florence - 632
BTF-0065A - 459
BTF-0065B - 173

Bearings In Aiken: Total 3,429
BTF-0065A - 1,630
BTF-0065B - 1,799

Bearings from Statum Warehouse: Total 1,496
BTF-0065A - 610
BTF-0065B - 886

3. Root Cause:

Inspection of seals produced at CR Bethlehem from the returned Aiken stock showed visible signs of potential leak defects for the following conditions: Unfills, manual knife trim damage, flowlines, and soft spots. In conversations with CR Bethlehem staff, they agree that these were major problems that the plant contended with during their production runs and any one of these defects may have caused the seal failures. The 6 seals that were returned from the field had enough wear that any of these defects may have been worn away. There is only 1 seal with remaining evidence of seal defects, which was a unfill (void) on the wiper lip. Due to the fact that all of the defects mentioned may have been worn away and each will be treated as a potential root cause of seal failure.

4. Corrective Actions:

1. Unfills (or voids) occurred on the wiper lip and on the bond tab on the side-wall of the part. There are several potential reasons why this occurred on CR Bethlehem production which are reflected on the Elgin PFMEA. However, it was identified that the root cause for the unfills was the lack of proper clearance in the mold to allow the metal stamping to fit into the mold. This lack of clearance in a nonfunctional portion of the mold did not allow the metal stamping to fully seat in the mold cavity. As the rubber entered the mold cavity to fill out the seal, the proper rubber path was reduced by the unseated metal stamping. In some cases, the force of rubber never overcame this resistance soon enough and the rubber cured up before filling out the seal. This created unfills (voids) on both the wiper lip and on the side-wall of the part. The corrective action was to remove the interference point to allow the metal to seat fully in the mold. This is located in a nonfunctional portion of the mold. There is no change to dimensional data, and this was confirmed with dimensional verification which was included in the PPAP to Aiken.

7-Step Corrective Action.

2. Regarding the potential for Dirty Mold, we concur with the findings from original TER completed by CR Bethlehem on this part number. Elgin follows similar procedures for auditing and inspecting for dirty mold and follows a break in process with mold release to prevent Dirty Mold from causing seal defects. However, there is one addition corrective action. Michurn Mold Release used during CR Bethlehem production is acceptable with 490 rubber, however there is a newer technology mold release agent that is available. This product (Chemtrend) is used for all 490 rubber during the break in and molding process. This substitute product allows the mold to run cleaner and substantially reduces the potential for this failure to occur.

3. Next, the damaged to the primary lip was caused by manually trimming the part with a knife blade. The need for trimming arouse due to the high picker flash left on the part. The high picker flash is caused by damage to the gate area of the mold, but is controllable by mold release and press parameters. In Elgin production, there has not been any trouble with high picker flash thus far. Regardless, there are 2 corrective actions. One, if any picker flash does occur, the parts will be scrap, instead of reworking with a knife trim. Secondly, if picker flash does become an issue, the corrective action will be to replace any mold cavities with damage to the gate area with replacement mold inserts and re-qualify the mold internally.

4. Flowlines on the contact points is noted on both CR Bethlehem and Elgin production. Re-facing the radial grind on the lands of the mold cavity is a routine maintenance item needed to be completed when the mold arrived in Elgin. This process allows for air to escape the mold as the rubber enters the cavity. In addition, mold release can create flowlines, for which, the fore-mentioned changes to mold release and re-facing of the lands helps to control this defects.

5. Verification:

Although each of the defect conditions covered above are controllable as described, each part will be is 100% visually inspected. However, as an additional verification, a 100% functional test will be conducted on all seals. The test (Air Leak Down) will be performed before the assembly process. The Leak Down process will sort out all of the defects listed above and prevents any molding defects from being assembled and shipped. The Leak Down is performed by putting the seal into a fixture that seals at both contact points. Then, air is introduced into the fixture and the test equipment measures the rate of air pressure decay. Any leak path caused by molding defects will be detected by the lack of ability for the seal to contain the air pressure. This leak test simultaneously checks the wiper lip and primary lip of the seal. MSA for Leakdown has validated the effectiveness of the test.

All corrective actions were completed before start of production in Elgin with the exception of the air Leak Down. All seals produced before implementation of Leakdown were 200% inspected to "oil seal" standards which have Zero Allowable defect size or quantity on the sealing surfaces. The Leakdown equipment is complete and will ready for production 4-25-2002. Implementation and training is being completed and from this point forward, all seals will be 100% leak down tested as an added precaution.

UPDATE 5/23/2002

The final action item for 100% leakdown testing was implemented on 4/25/2002. On 4/30/2002, the 1000 piece shipment contained only 100% leakdown tested parts, as well as all other shipments since that date.

7-Step Corrective Action.

UPDATE 07/18/02

Attribute Gage R&R Study - This is a pass fail MSA using known good and bad parts.

Within Appraiser

Assessment Agreement

Appraiser #	Inspected #	Matched	Percent (%)	95.0% CI
1	8	8	100.0	(68.8, 100.0)
2	8	8	100.0	(68.8, 100.0)

Matched: Appraiser agrees with him/herself across trials.

Between Appraisers

Assessment Agreement

# Inspected	# Matched	Percent (%)	95.0% CI
8	8	100.0	(68.8, 100.0)

Matched: All appraisers' assessments agree with each other.

Gage R&R for Leakdown unit -This gage R&R uses the same parts as the MSA above. By including these parts and increasing the decay time we were able to get enough discrimination to validate the machine.

Note the number of distinct categories compared to the initial MSA. The length of decay was determined by measuring parts over various decay times in order to see readings other than zero which we experienced with good parts at the our normal 1 second decay time. We also had to change the leak down limit in order to obtain a reading for the bad parts included in the MSA. Normally a bad part will provide a decay value equal to the decay limit. By increasing the decay limit to a value greater than the actual leak, we could see the amount of the actual leak and use it for the MSA. Please call if you need more information

Source	VarComp	%Contribution (of VarComp)
Total Gage R&R	0.001181	1.86
Repeatability	0.000688	1.08
Reproducibility	0.000493	0.78
Operator	0.000037	0.06
Operator*Parts	0.000456	0.72
Part-To-Part	0.062389	98.14
Total Variation	0.063570	100.00

SKF 001308

7-Step Corrective Action.

Source	StdDev (SD)	Study Var (5.15*SD)	%Study Var (%SV)
Total Gage R&R	0.034371	0.17701	13.63
Repeatability	0.026236	0.13511	10.41
Reproducibility	0.022204	0.11435	8.81
Operator	0.006089	0.03136	2.42
Operator*Parts	.021353	0.10997	8.47
Part-To-Part	0.249777	1.28635	99.07
Total Variation	0.252131	1.29847	100.00

Number of Distinct Categories = 10

6. Control:

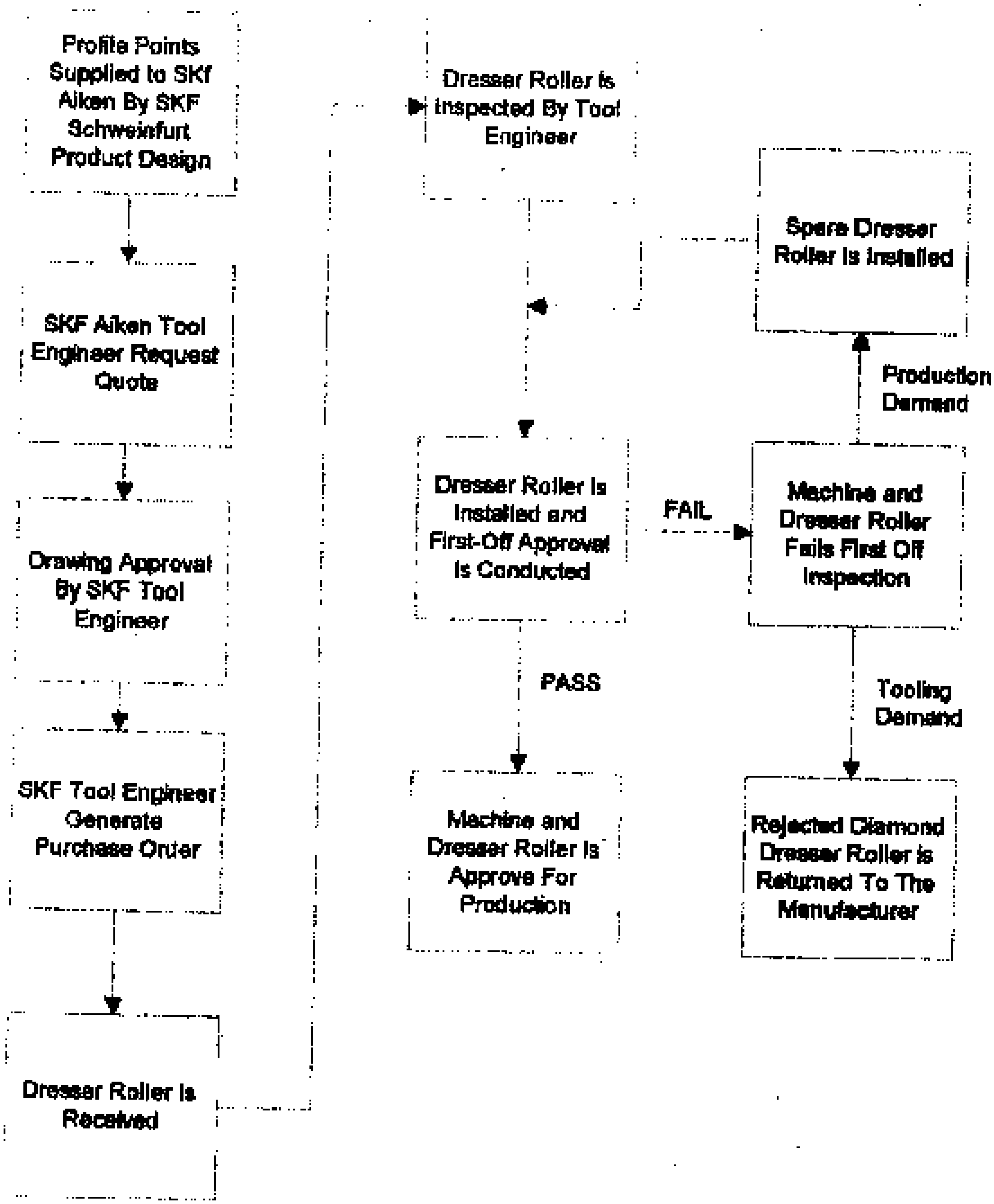
Control is achieved via a Leakdown Machine "Setup/In-Process Verification Log". The verification is performed by testing known master samples through the leakdown equipment to verify that it is working properly. This is done at each set up and every 2 hours.

7. Prevention:

All of these controls are part of the Control Plan and considered permanent part of the process routing.

Chris Jones
Quality Assurance Manager
SKF Automotive Division
Aiken.

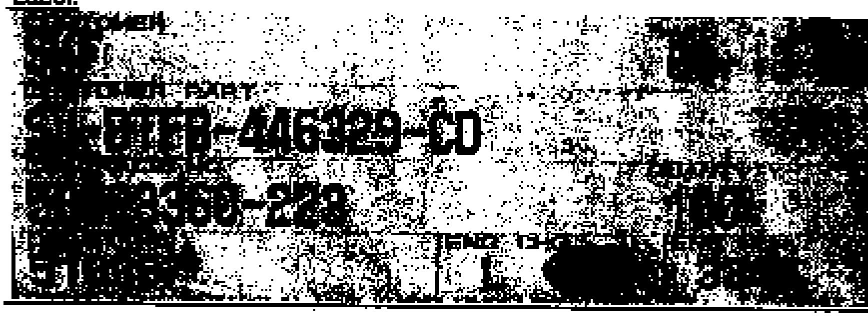
DIAMOND DRESSER ROLLER APPROVAL FLOWCHART



SKF 001320

Traceability documentation for BTF 0065 Part designation: **R - Safe Seal** Part number: **SV - BTFB - 446329 CD**	Date: ....

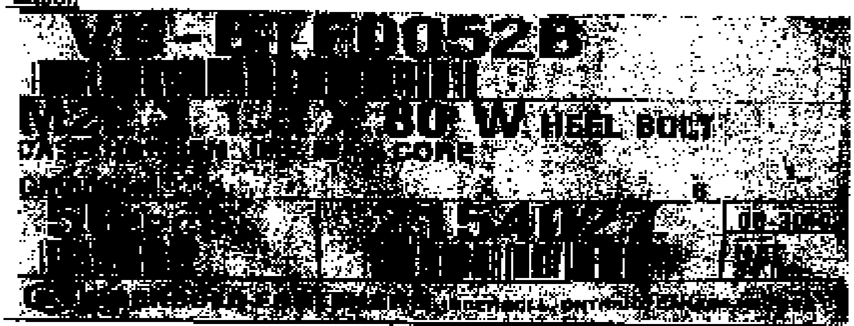
Label:



Julien date:	Batch lot number:	Incoming release date	Remarks:

Traceability documentation for BTF 0065 Part designation: **Stud** Part number: **VB - BTF - 0052 B**	Date: ....

Label:



Julien date:	Batch lot number:	Incoming release date:	Remarks:

Traceability documentation for BTF 0065

Part designation: ABS ring

Part number: VF - BTF - 0031

Date:

....

Label:

Part No. VF-BTF-OC...

Qty. 144

Weight 358

P.O. No. M12334

Line 2

Date 7-2-02

ACCEPTED

Date 1/12/02

Julien date:	Manufacturing date / Check Tag number	Incoming release date: Remarks; Remarks:

Traceability documentation for BTF 0065

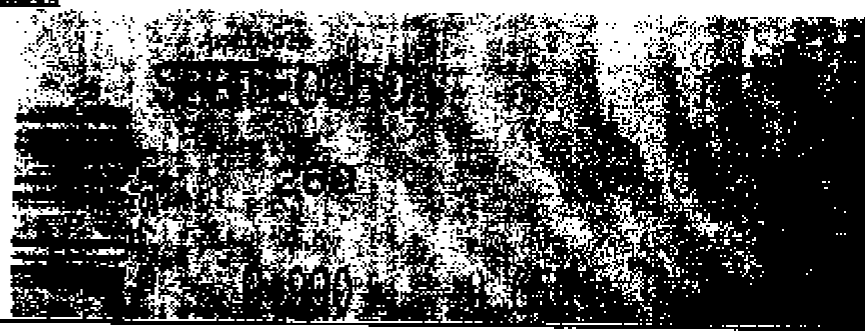
Part designation: **Seal**

Part number: **SR - BTF - 0050**

Date:

....

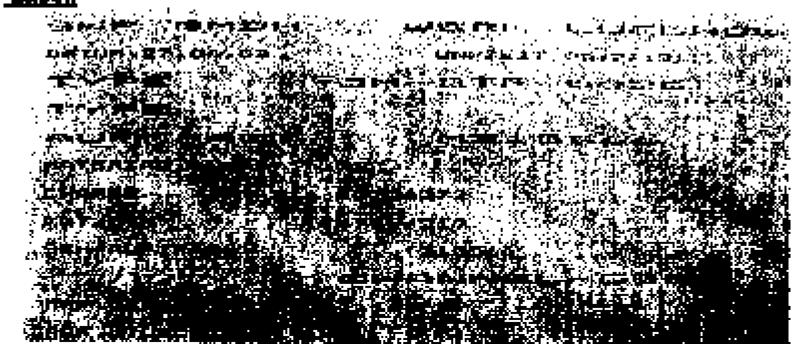
Label:



Julien date:	Manufacturing date:	Incoming release date:	Remarks:

Traceability documentation for BTF 0065 Part designation: **Inner Ring Forge** Part number: **JM-BTF-0025**	Date: ....

Label:

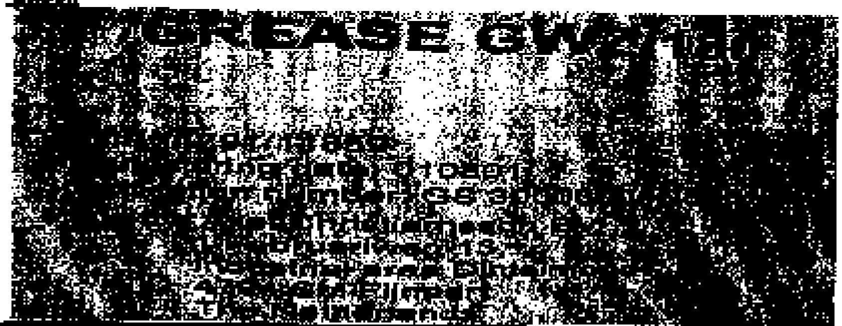


Julien date:	Referenct to order no. / heat number	Incoming release date:	Remarks:

SKF 001325

Traceability documentation for BTF 0065 Part designation: **Grease** Part number: **Grease GWZ**	Date: ....

Label:

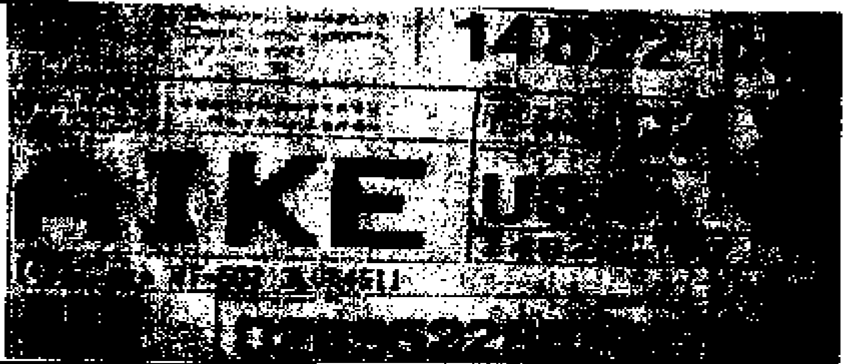


Julien date:	Reference to Batch / Lot No.:	Incoming release date:	Remarks:

SKF 001326

Traceability documentation for BTF 0065 Part designation: **Rollers** Part number: **RT 502L**	Date: ....

Label:

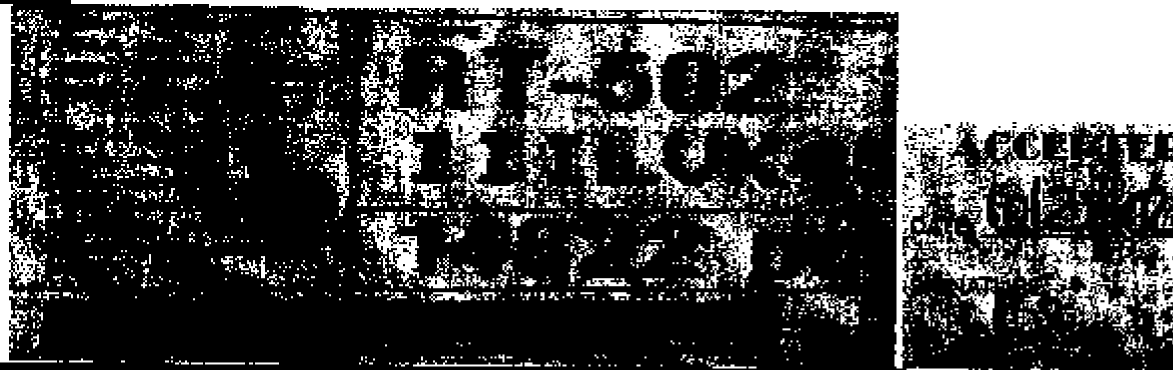


Julien date:	Reference to delivery date:	Incoming release date:	Remarks:

SKF 001327

Traceability documentation for BTF 0065 Part designation: **Rollers** Part number: **RT 502L**	Date: ....

Label:

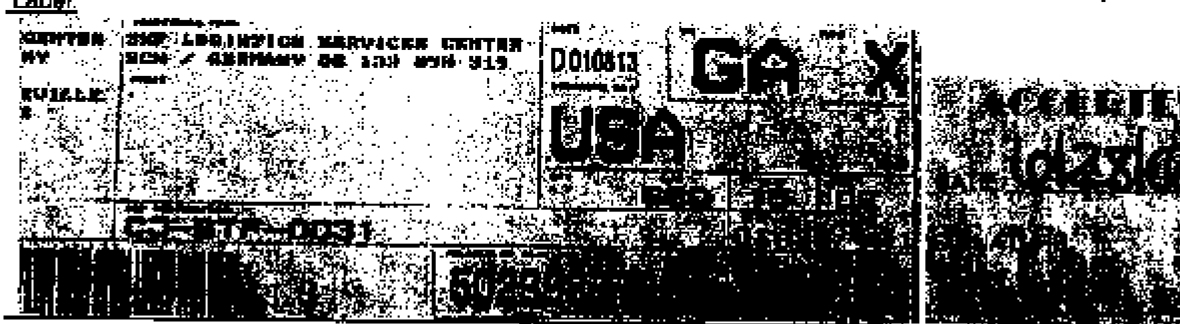


Julien date:	Reference to assembled part:	Incoming release date:	Remarks:

SKF 001328

Traceability documentation for BTF 0065 Part designation: **Cage** Part number: **CJ-BTF-0031**	Date: ....

Label:



Julien date:	Reference to assembled part:	Incoming release date:	Remarks:

Traceability documentation for BTF 0065

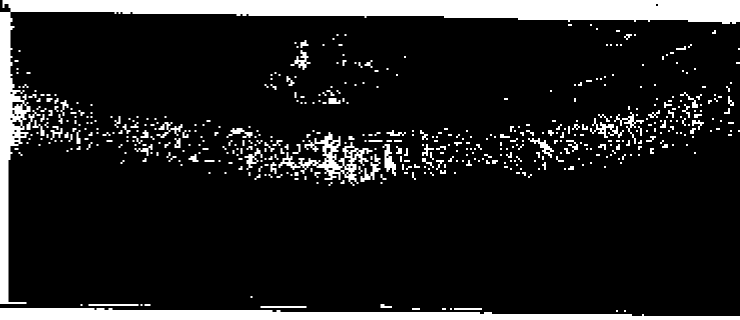
Part designation: **Outer Ring Forge**

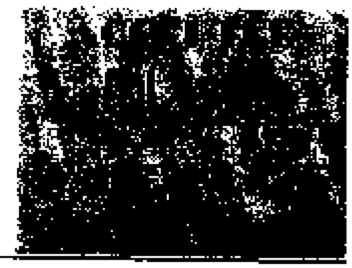
Part number: **OF-BTF-0075**

Date:

....

Label:





Julien date:	Reference to Die Code	Incoming release date:	Remarks:

Traceability documentation for BTF 0065 Part designation: .... Part number:	Date: ....

Label:

Julien date:	Reference to assembled part:	Incoming release date:	Remarks:

Traceability documentation for BTF 0065

Date:

....

Part designation: ....

Part number: ....

Label:

Julien date:	Reference to assembled part:	Incoming release date:	Remarks:

Traceability documentation for BTF 0065

Part designation: ....

Part number: ....

Date:

....

Label:

Julien date:	Reference to assembled part:	Incoming release date:	Remarks:

Subject: Internal geometry - Aiken April/May 99

Category: Quality

Overview on internal geometry data from Aiken from april/may 1999::

Results show that in april / may 1999 were no process deviations for IR-raceway angle, IR-raceway crowning, flange angle that could explain the exceeded number of rejections from the field.

BTF-0065 Monthly Internal Geometry Results_aprmay!

Discussion

Subject: ERC Investigation Reports

Category:

NL02T903e_Supplement.dc NL02M903e.doc NL02M904e.doc NL02T903e.doc NL02M902e.doc

NL02M906e.doc

SKF 001344

ArvinMeritor THUs from the Field: Bore Corrosion Product Analysis

Aidan Kerrigan

Materials Theory & Testing

EXTERNAL CUSTOMER
Report Supplement on Project No. N02 184

Supplementary Information on:

NL02MT903a
2002-07-31

ArvinMeritor THUs from the Field: Bore Corrosion Product Analysis

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Key Words University of Surrey, x-ray photoelectron spectroscopy, iron oxide, corrosion, aqueous, humid

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SKF 001346

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ArvinMeritor THUs from the Field: Bore Corrosion Product Analysis

Abstract The inner ring of a THU from the field was supplied to the University of Surrey, UK, for analysis using x-ray photoelectron spectroscopy. The objective was to determine the chemical species of various areas of the bore, which were different in appearance.

Project background

There have been incidents with THUs in the field in the USA. Examples of THUs from the field were supplied to ERC for investigation. One specific question was regarding the corrosion products seen on the bore of the inner rings. In the bore, at the highest loaded position (nominated as 0°), there was a darkened red area, which would normally be classed as fretting corrosion. However, there was also a light red area at the 180° position, which was regarded as unusual. In general, the chamfer was not discoloured but there was a free-standing red area on the chamfer i.e. in a non-contacting location.

In order to classify these products, an inner ring was supplied to the University of Surrey, UK, for analysis using x-ray photoelectron spectroscopy (XPS). This technique is used to determine the chemical species by measurement of the chemical bonding energies.

It is important to state that the University of Surrey were not given any information other than that the part supplied was a taper roller bearing inner ring and given clear instructions of the areas to analyse. No manufacturing, application or customer information was given. As a result, the investigation and report from the University (incorporated into this report in its entirety) covers more than just the oxide species.

Objectives

To determine the chemical species present in the bore of a THU inner ring returned from the field.

Main results

According to the results and interpretation from the University of Surrey, the products in the bore of the THU inner ring at the 0° and 180° positions were an Fe(III) compound, most probably FeOOH, which were formed in a humid environment i.e. in the presence of water.

It should be noted that at the 0° position, the finish machining marks were not apparent but that at 180°, the finish machining marks were still visible.

On the (non-contacting) chamfer, the non-discoloured surface had an Fe_2O_3 type of deposit. This was stated to have been formed in a dry environment, at a 'slightly elevated' temperature, probably during heat treatment.

The free-standing red area on the chamfer was analysed and also found to be an Fe_2O_3 type of deposit, again formed in a dry environment.

The remarks about carbon for the areas on the chamfer are possibly explained by the fact that the general surface will have an oxide which formed during austenitising and was then oil quenched, picking up carbon. The other area may have formed after the quenching treatment, giving a lower carbon content. Note that this is very speculative.

The results at the 0° and 180° positions in the bore, as compared to the results from the chamfer, indicate that the technique can differentiate between different oxide species.

Main conclusions and recommendations

The products in the bore of the THU inner ring at the 0° and 180° positions were an Fe(III) compound, most probably FeOOH, which were formed in a humid environment i.e. in the presence of water.

Additional comments

For clarity, the codes used by the University of Surrey will be explained here in relation to the ERC description of the products in the bore.

ERC		University
0° in bore :	Darkened red area	SKF 01
180° in bore :	Light red area	SKF 02
Chamfer :	Free-standing red area	SKF 03
Chamer :	Non-discoloured area	SKF 04

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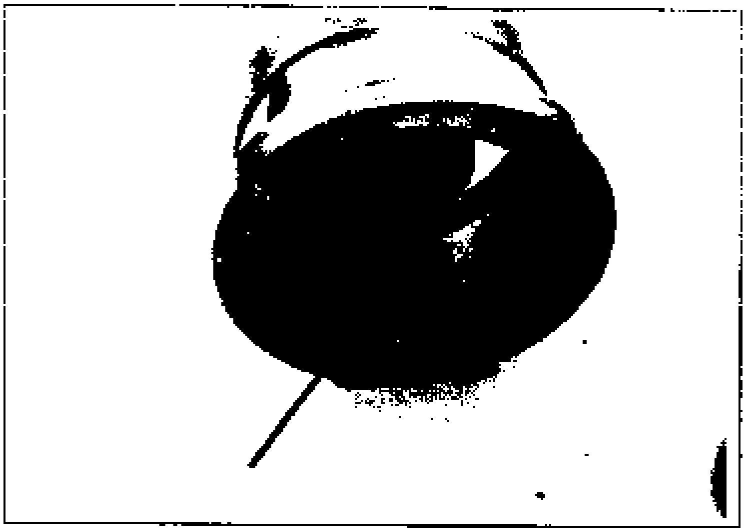
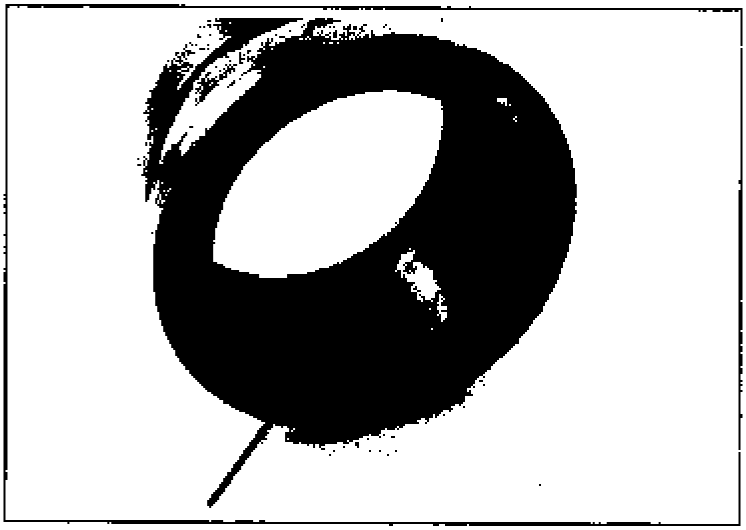
Photographs supplied to the University of Surrey



Darkened red area on bore (0°)



Light red area on bore (180°)

Free-standing red area on chamfer

SKF 001346

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UniS

XPS Analysis of Discolouration on Bearing Inner Ring #11

J F Watts & S J Greaves

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July 2002

Prepared for:
SKF Engineering & Research Centre BV

Commercial in Confidence

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XPS Analysis of Discolouration on Bearing Inner Ring #11

J F Watts, S J Greaves

Executive Summary

Surface chemical analysis of "Bearing Inner Ring #11" was carried out by X-ray photoelectron spectroscopy (XPS). XPS is a surface chemical analytical technique with an analysis depth of approximately 8 nm. Samples were cut from the bore and the chamfer of "Bearing Inner Ring #11", these were identified (by the customer) as darkened red area in bore (SKF01), light red area in bore (SKF02), free-standing red area on chamfer (SKF03). In addition an analysis from an unblemished region of the chamfer (SKF04) was also required.

Analyses from specimens within the bore indicate both the darkened red and the light red discolouration (SKF's descriptions) to arise from an Fe(III) compound, most probably FeOOH, which has been formed in a humid environment.

Both analyses indicate significant surface concentrations of surface carbon contamination which is predominantly hydrocarbon in nature with the presence of some C=O organic functionalities.

The analyses from the chamfer are both of an Fe_2O_3 type of deposit. The one identified as a free-standing red area on the chamfer is a voluminous (high surface area) form whilst that from the unblemished region of the chamfer is a thin passive film of the same composition probably resulting from a heat treatment procedure at some point in the ring's thermal history.

Minor elements (Ca, Na, F, K and N) are detected in low concentrations at all analysis positions but it is not possible to relate these, either qualitatively or quantitatively, to the performance of the bearing ring in service on the information supplied.

SKF 001350

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XPS Analysis of Discolouration on Bearing Inner Ring

J F Watts, S J Greaves

Preamble

A bearing shell identified as "Inner Bearing Ring #11" was supplied complete by the customer along with a series of digital photographs that identified regions of concern regarding the physical appearance on both the bore of the bearing and the region identified as the chamfer. The descriptions of these regions of discolouration, and those that are used in the following reports are as follows:

Darkened red area in bore
Light red area in bore
Free-standing red area on chamfer

In addition we were also instructed to carry out analysis on a region of the "chamfer" that was not discoloured, this is identified as:

Non-discoloured area on chamfer

In the attached spectra these analysis zones are given the following codes:

SKF01
SKF02
SKF03
SKF04

The bearing shell was sectioned in University of Surrey workshops to provide relatively large pieces of the bearing ring for analysis, with the regions of interest identified in the customers photographs. Large specimens were used in order to avoid thermal effects that will be present near the machined surfaces, no cutting fluid was used to avoid the possibility of the modification of the surface chemistry of the regions of interest by the use of such reagents. A series of views of the sectioned bearing ring is shown in Figure 1.

XPS Analysis

The sectioned specimens were mounted for analysis on the platen of our Thermo VG Scientific Sigma Probe spectrometer. Analysis was carried out using AlKα radiation, and a survey spectrum over the region 0 – 1340 eV (binding energy) was first recorded from each region at a channel width of 0.4 eV. High resolution spectra were recorded on the basis of the elements identified in the survey spectrum. These were typically C1s, O1s, N1s, F1s, Ca2p, Fe2p, Na1s, depending on the specimen. All survey spectra and high resolution spectra acquired are appended to this report. The binding energies of the principal photoelectron core levels observed are listed in Table 1.

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SKF 001351

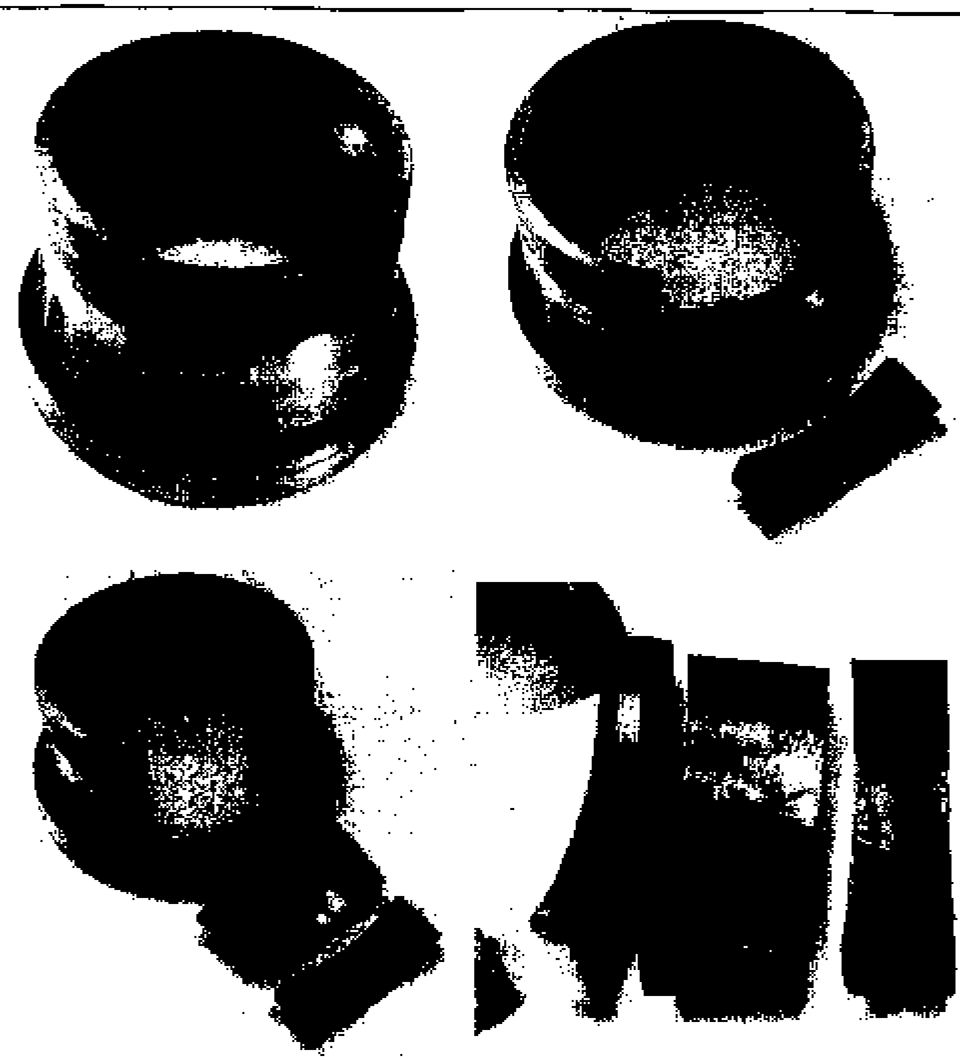

Figure 1. General views of bearing inner ring following sectioning.

C1s	285
N1s	400
O1s	530
F1s	686
Na1s	1072
Ca2p	347
Fe2p3/2	710

Table 1. Binding energies of the major photoelectron lines

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Quantitative Surface Chemical Analyses

Quantitative analyses were calculated from the high resolution spectra following background removal to yield the peak intensity in counts sec^{-1} eV, this is then normalised using the appropriate atomic

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sensitivity factor (SF) to yield a normalised peak which is then summed to provide the surface composition in atomic percent (At. %). These data are provided for spectra SKF01 – 04 in Tables 2-5. In all cases a small amount of potassium is detected as revealed by the presence of the K2p doublet centred at 295 eV

C1s	55.5	0.25
Ca2p	0.5	1.58
F1s	2.7	1
Fe2p	9.3	3
N1s	1.2	0.42
Na1s	0.9	2.3
O1s	29.9	0.66
K2p	trace	1.24

Table 2. Surface analysis derived from spectra SKF01 (darkened red area in bore).

C1s	64.3	0.25
Ca2p	0.4	1.58
F1s	1.2	1
Fe2p	8.1	3
N1s	0.9	0.42
Na1s	1.1	2.3
O1s	24.0	0.66
K2p	trace	1.24

Table 3. Surface analysis derived from spectra SKF02 (light red area in bore).

C1s	15.1	0.25
Ca2p	0.2	1.58
F1s	0.4	1
Fe2p	30.0	3
N1s	0.7	0.42
Na1s	1.1	2.3
O1s	51.2	0.66
K2p	1.2	1.24

Table 4. Surface analysis derived from spectra SKF03 (free-standing red area on chamfer).

C1s	47.8	0.25
Ca2p	0.2	1.58
F1s	0.7	1
Fe2p	14.4	3
N1s	1.3	0.42
Na1s	1.3	2.3
O1s	34.1	0.66
K2p	0.2	1.24

Table 5. Surface analysis derived from spectra SKF04 (non-discoloured area on chamfer).

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Carbon 1s Data

The concentrations of carbon observed on these specimens are, in three cases, at a level to be expected from samples that have been exposed to the ambient environment in a relatively uncontrolled manner, with perhaps the presence of residual carbonaceous material from previous processes. In the case of the spectra recorded from the free-standing red area on the chamfer (SKF03) this value is much lower at 15 at %. This is unusual and provides significant clues to the form of the visually identified deposit, it is of a high surface area type and has formed within a relatively recent timescale, as it has not been contaminated in the manner the other regions have experienced.

Minor Elements

Small surface concentrations of Ca, Na, F, K and N are detected on all specimens. Ca is often associated with tap water and is slightly higher on analyses recorded from the bore than the chamfer regions. F is significantly higher on analyses from the bore than the chamfer and it is not possible at this stage to speculate on the source of this element. Na is a common contaminant from physiological media and does not vary significantly between the different specimens. Likewise the N levels seem fairly consistent from one to another. K is significantly higher on the specimen SKF03 and this most likely indicates it is intimately associated with the corrosion product. In other samples the higher surface concentration of carbon attenuating the K2p signal.

Chemical State Information

Although most of the high resolution spectra contain little information of spectroscopic significance the Fe2p, O1s and C1s spectra are particularly informative.

Iron 2p Spectra

The 2p region recorded shows both the Fe2p3/2 and Fe2p1/2 components resulting from the spin orbit splitting of the Fe2p electrons. The binding energy is consistent with the Fe(III) state and this is confirmed by the presence of Fe2p3/2 satellite structure on the higher binding energy side of the valley between the Fe2p3/2 and Fe2p1/2. Thus the outer regions of the deposit (at the depth analysed by XPS, ca. 8 nm) is Fe(III) state in all cases. Fe(III) is the equilibrium phase likely to be formed in an excess of corrodent (oxygen or water), in a reduced partial pressure of oxygen Fe(II) is more likely to form.

Oxygen 1s Spectra

In the case of spectra SKF01 and SKF02, the O1s spectra [figures 8 and 16] have two well defined components at approximately 530 and 533 eV. Such observations are consistent with oxide and hydroxide components, indicating that the terminal phase is most probably FeOOH. This is the reaction product associated with the corrosion of iron in an aqueous (damp) environment. Indeed the exposure of pure iron to water vapour in clean, UHV conditions gives rise to a thin film this compound as does the exposure of mild steel to the ambient environment for short times of a few days.

The other spectra, SKF03 and SKF04 have an altogether different form of O1s line [figures 24 and 32]. In these cases the oxide component at 530 eV is dominant and the hydroxide contribution is merely observed as a broadening on the higher binding energy side. This is consistent with an oxide formed in a dry environment, possible at a slightly elevated temperature. The Fe2p and O1s data taken together indicate that the non-discoloured region (Specimen SKF04) is probably a thin (passive) film of Fe_2O_3 formed during the production process. The corrosion product (SKF03) is of similar chemical composition (Fe_2O_3) but of a more voluminous physical form.

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Carbon 1s Spectra

In all cases the spectrum is centred at a binding energy of ca. 285 eV as expected. This is the position typical of adventitious carbon and for charge referencing purposes this can be set to exactly 285.0 eV if required. All spectra have a higher binding energy component centred at approximately 288 eV which is attributed to carbon bonded to oxygen in the form C=O. In the case of the low carbon concentration (SKF03) this is associated with polar carbon adsorbed from the atmosphere but in the case of higher carbon concentrations such those observed on specimens SKF01, 02, 04, such polar contributions would be swamped by the apolar carbon. This leads to the conclusion that the source of carbon on these samples is something other than the usual adventitious material, i.e. a specific source which includes a carbonyl functionality.

Conclusions

The analysis by XPS of four regions of "Inner Bearing Ring #11" enable the following conclusions to be drawn:

- The characteristics of the analyses taken from the two regions within the bore ("darkened red area" and "light red area") are very similar.

- These two analyses (SKF01 and 02) show iron in the Fe(III) state and equivalent contributions of oxide and hydroxide which would arise from the formation of a FeOOH phase in a damp environment:

$$Fe + H_2O \rightarrow FeOOH$$

- $Fe_2O_3.2H_2O$ would have a dominant oxide component of the O1s spectrum but cannot be completely ruled out.

- The surface concentration of F is significantly higher for the SKF01 and 02 specimens than for SKF03 and 04.

- Analyses taken from the chamfer region (SKF03 and SKF04) both yield O1s spectra dominated by an oxide component, consistent with the corrosion product (SK03) and passive film (SK04) having formed in a dry environment, possible at elevated temperature.

- The corrosion product on the chamfer (SKF03) is of a high surface area and has not been exposed to gross hydrocarbon contamination (e.g. oil) since its formation.

- The surface concentration of potassium is higher in analyses taken from the chamfer than the bore.

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SKF Comment - by Aidan Kerrigan

The first and second conclusions in the report from the University of Surrey state that the species in the two positions of the bore of the inner ring (at 0° and 180°) have similar characteristics and match those that would be expected from the formation of FeOOH in a damp environment.

The third conclusion, which states '$Fe_2O_3.2H_2O$ would have a dominant oxide component of the O1s spectrum but cannot be completely ruled out', has been stated by the University of Surrey as there is a small possibility that the oxide is $Fe_2O_3.2H_2O$ rather than FeOOH. However, as is implied by the formula, $Fe_2O_3.2H_2O$ is also formed in a damp environment. Therefore, the main conclusion remains that the oxide species found in the two positions in the bore were formed in a damp environment.

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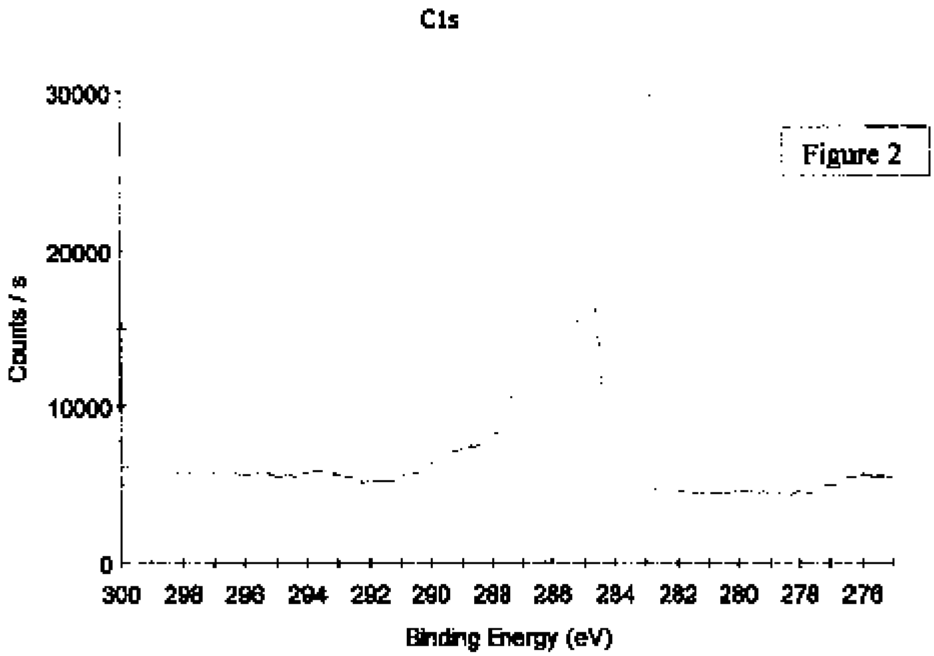
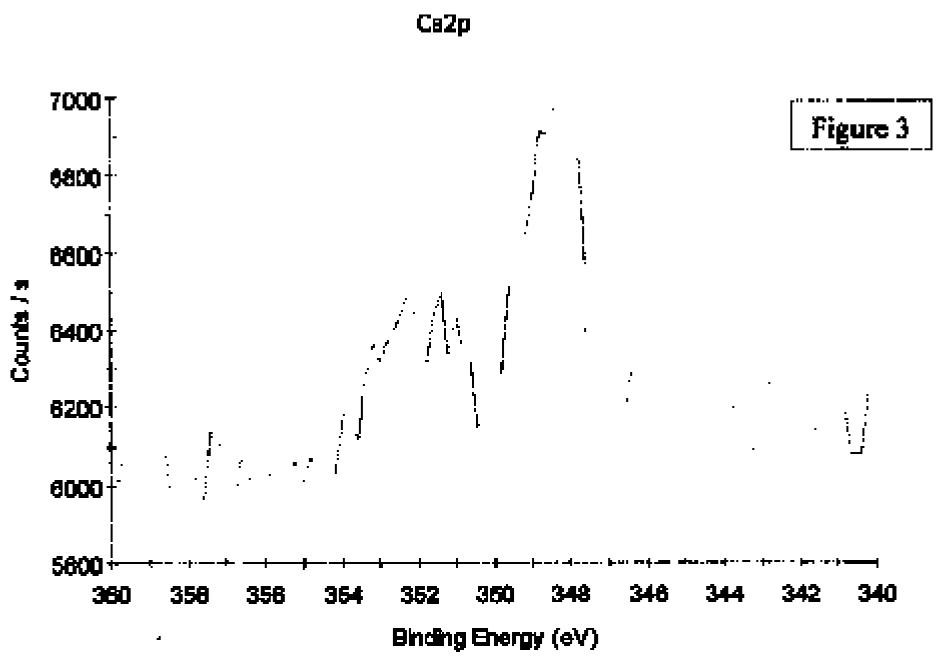
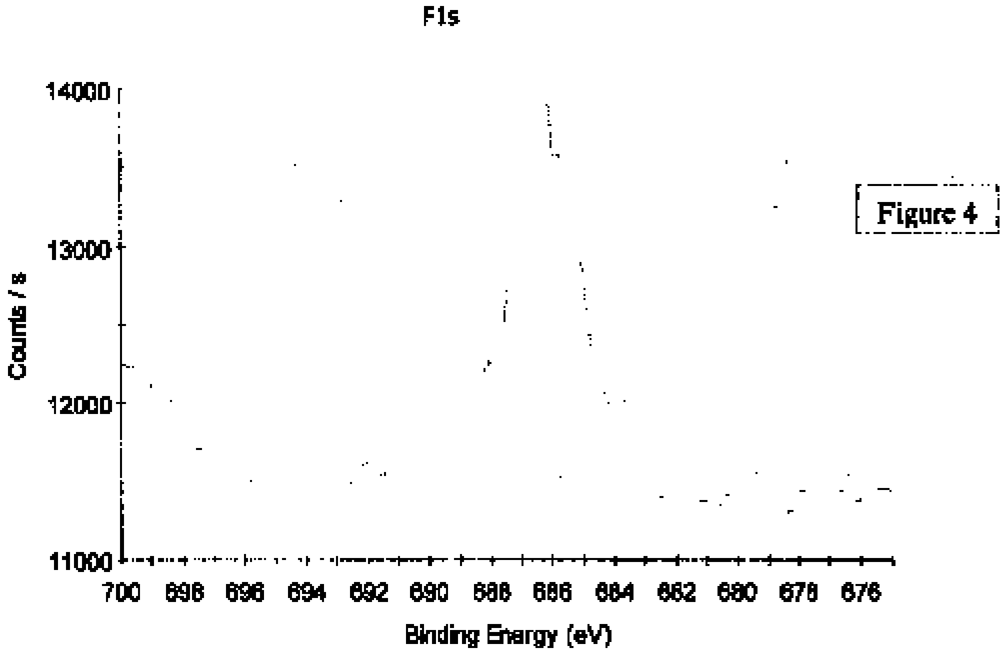
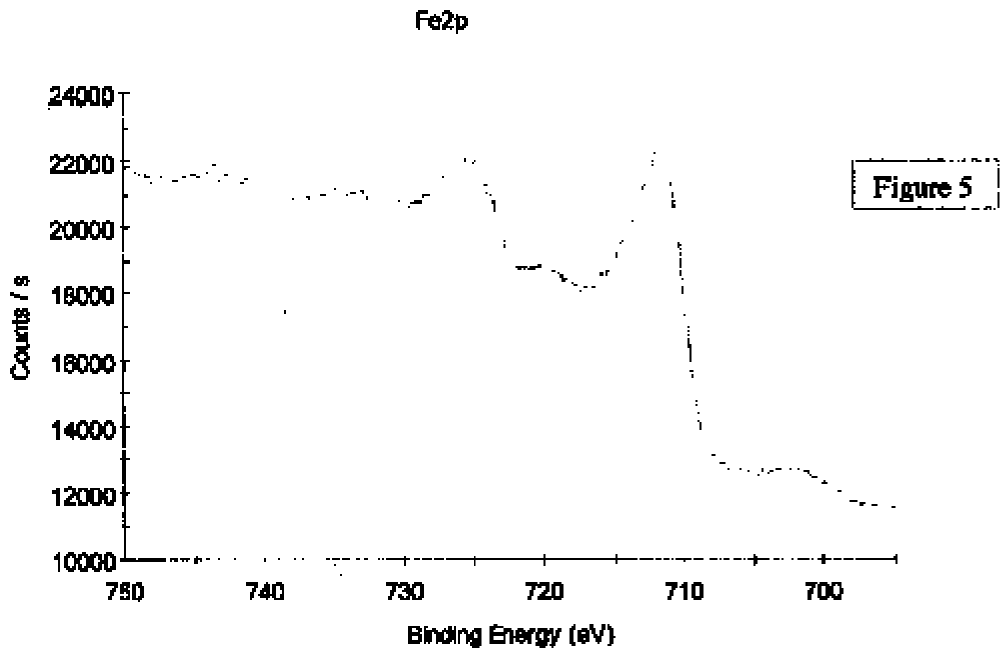
SKF01 Darkened red area in bore









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N1s

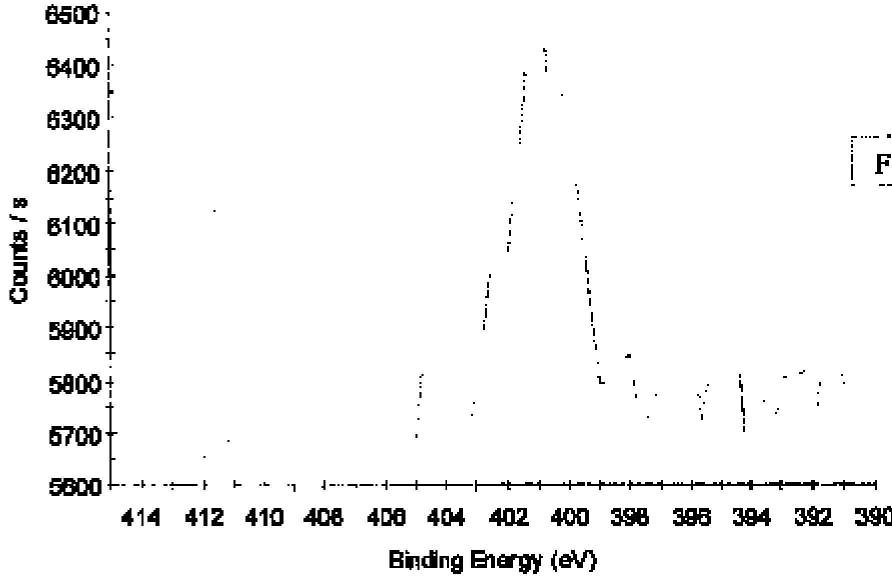

Figure 6

Na1s

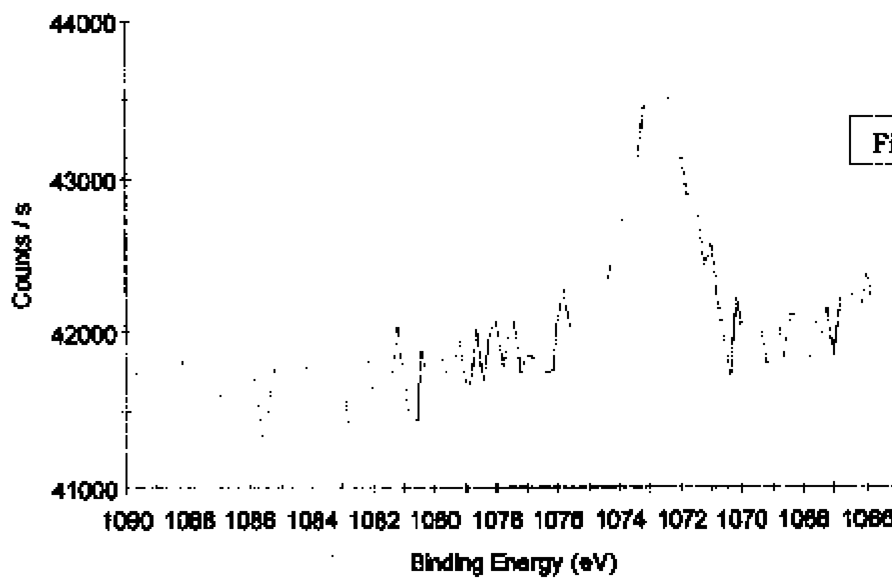

Figure 7

SKF 001369

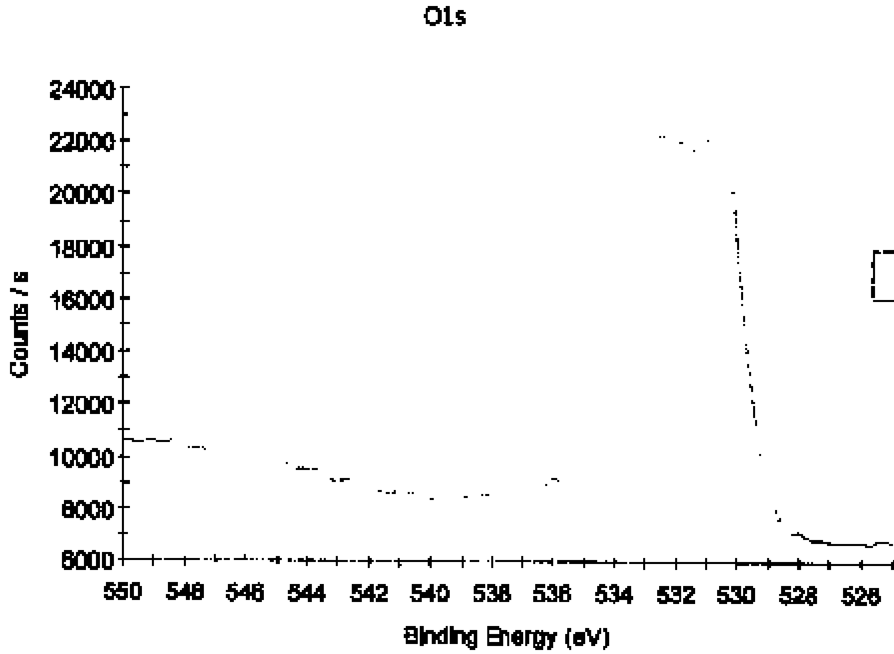

Figure 8

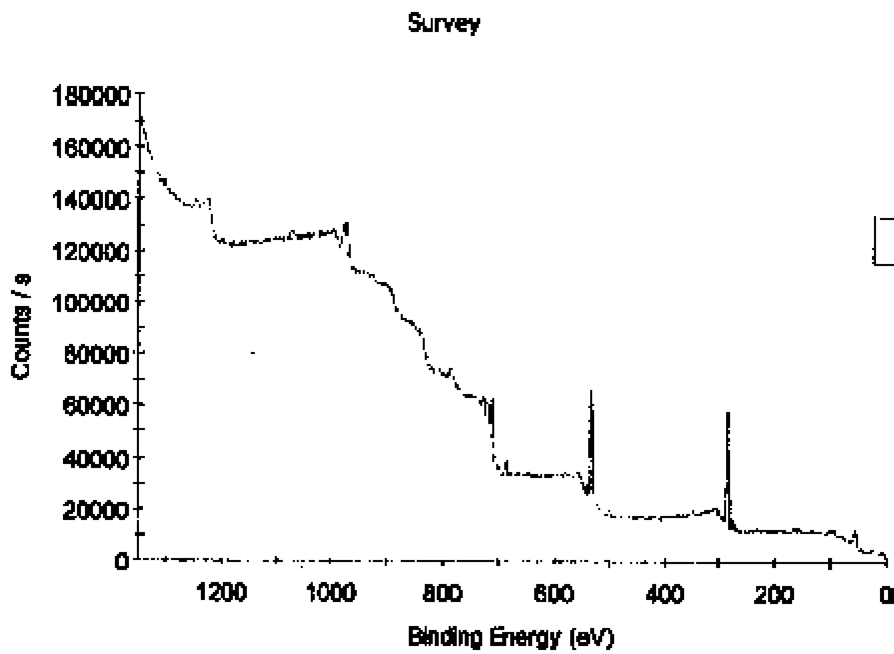

Figure 9

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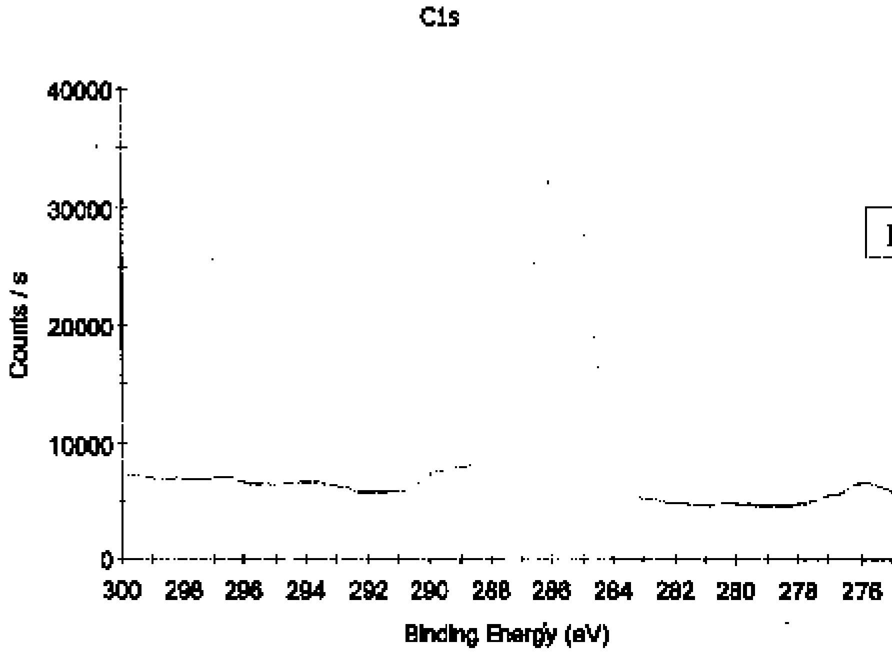
SKF 02 Light red area in bore



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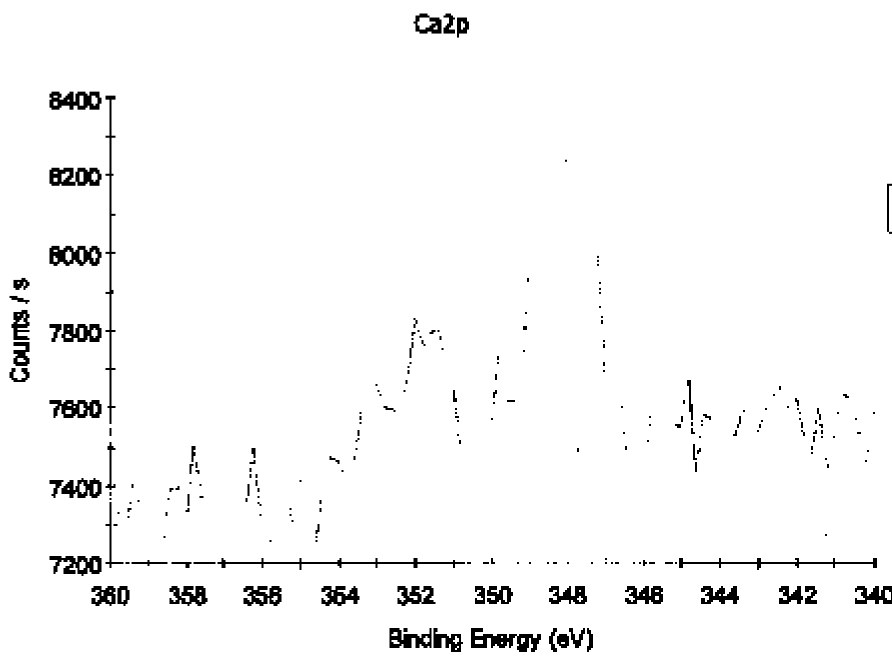

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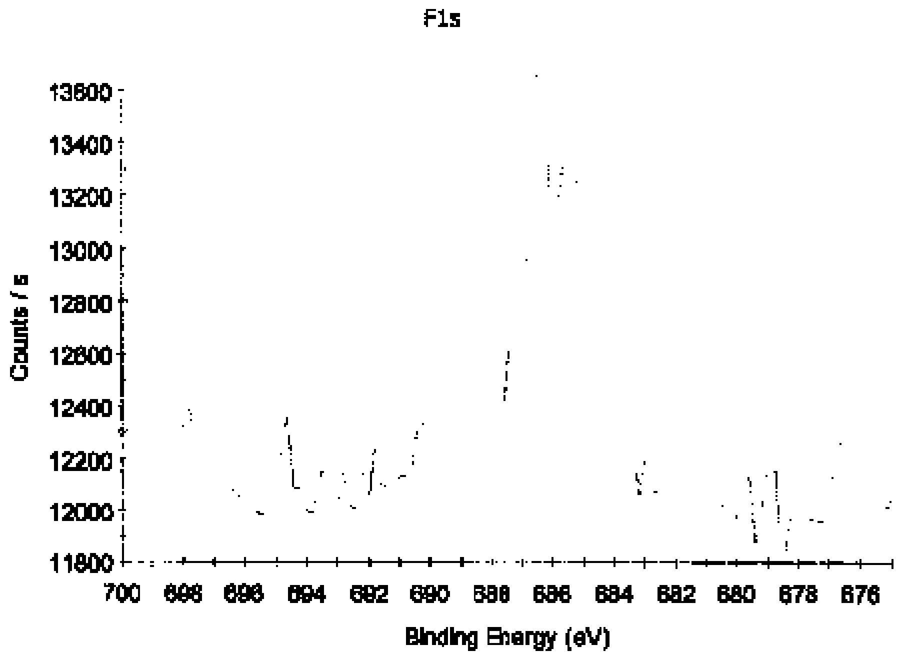

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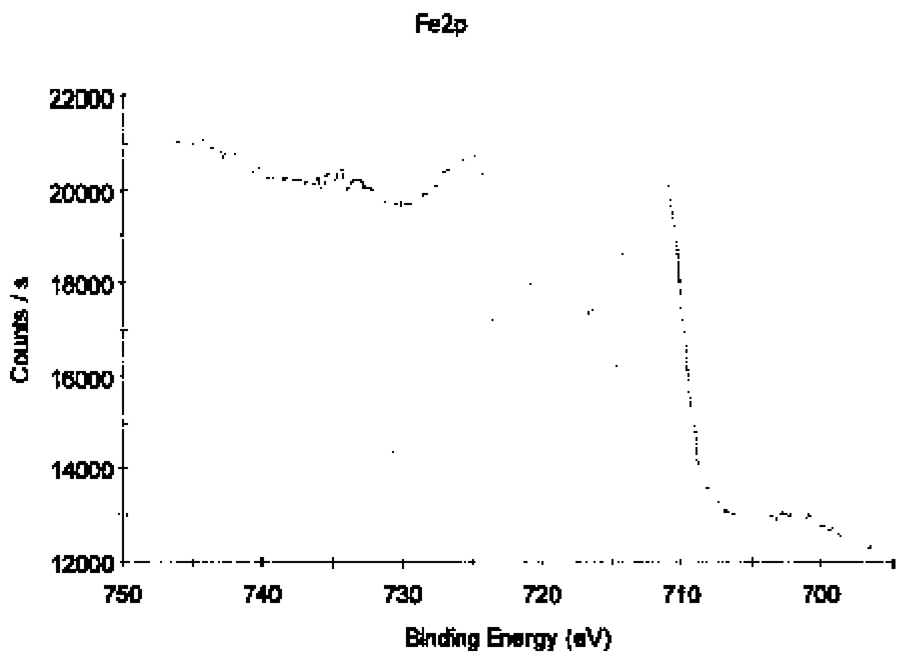

Figure 13

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N1s

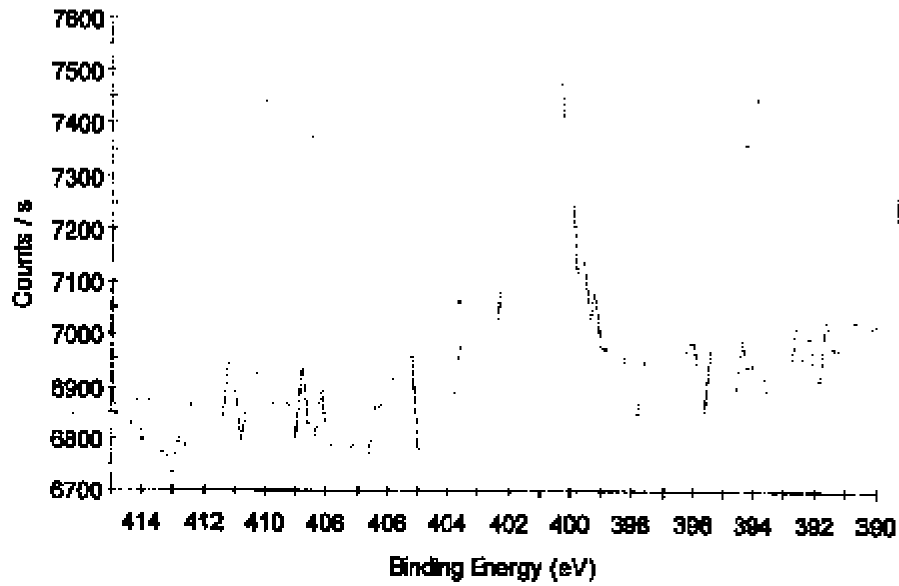

Figure 14

Na1s

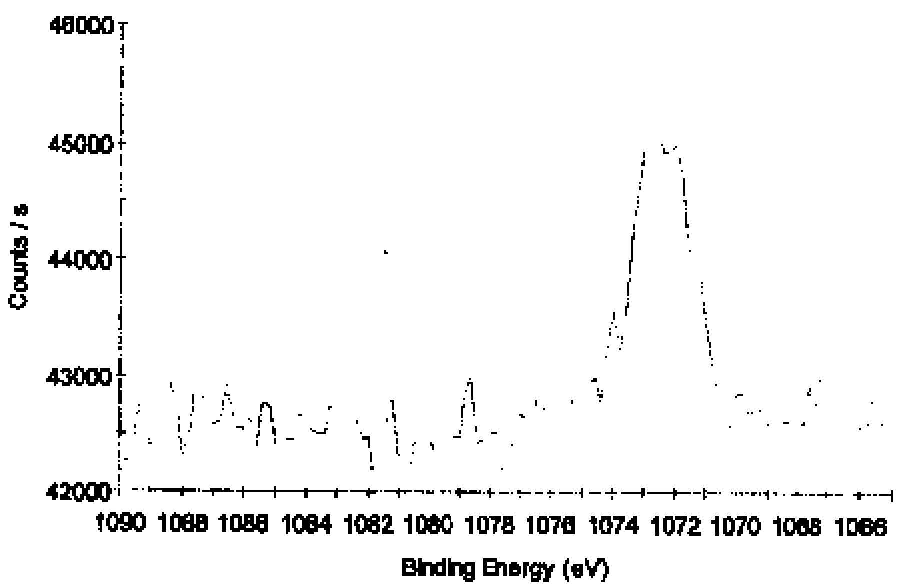

Figure 15

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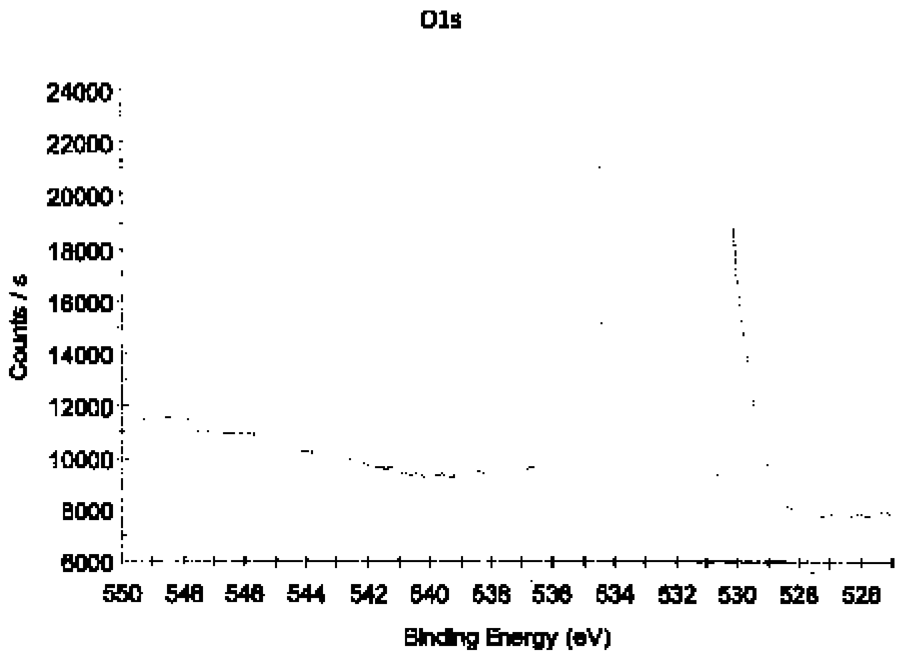

Figure 16

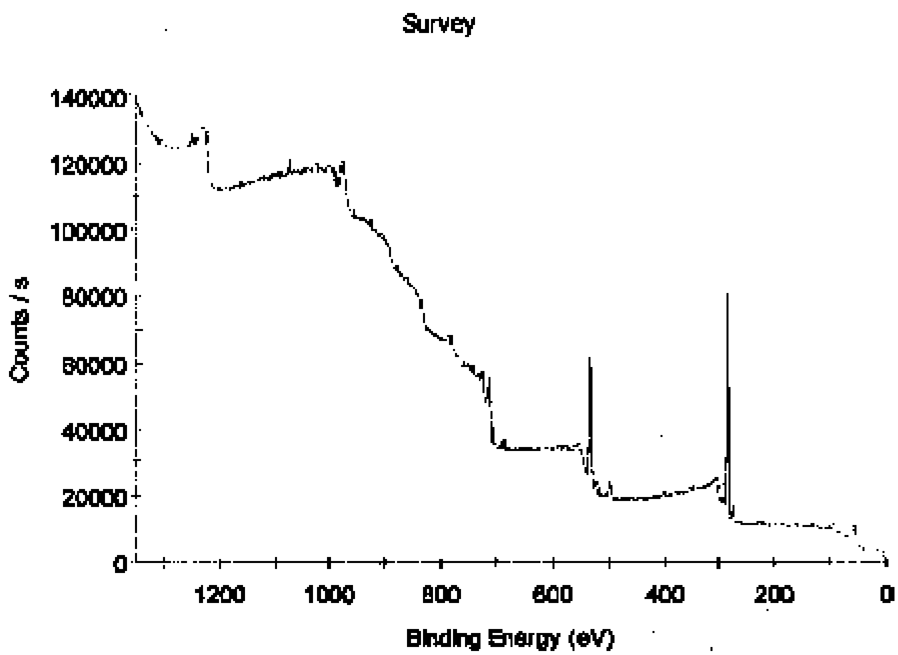

Figure 17

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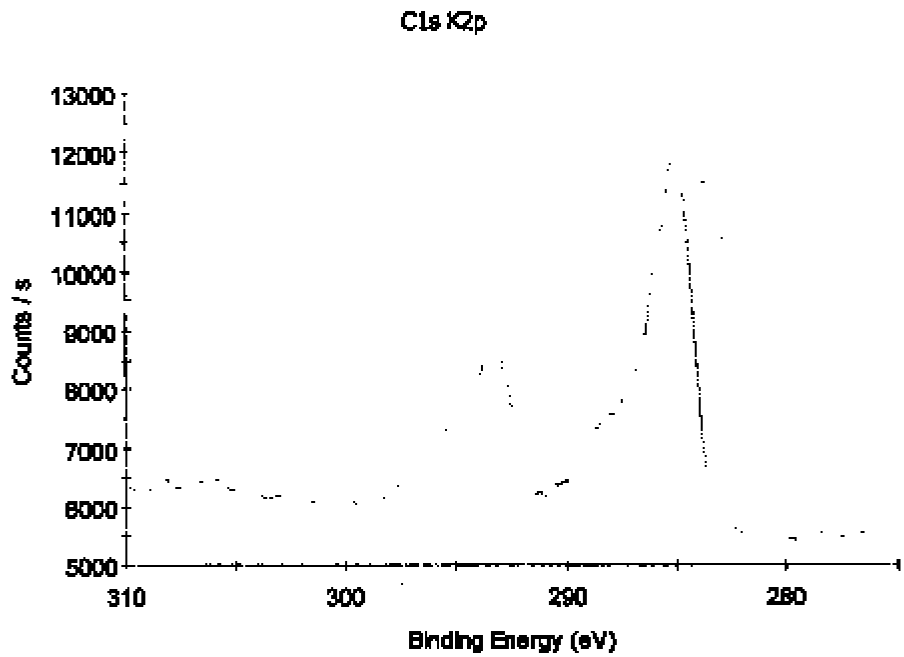
SKF 03 Free-standing red area on chamfer



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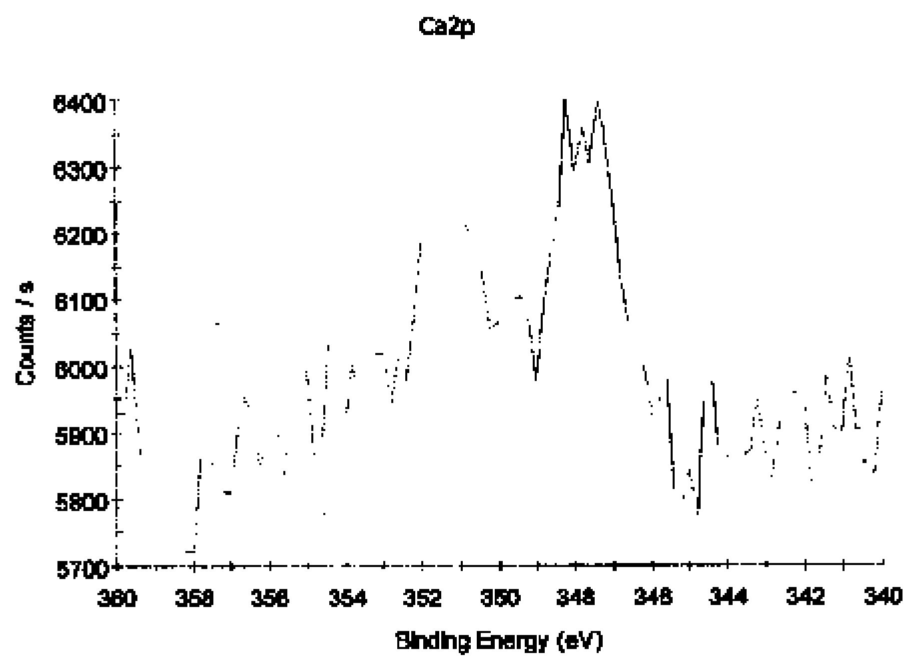

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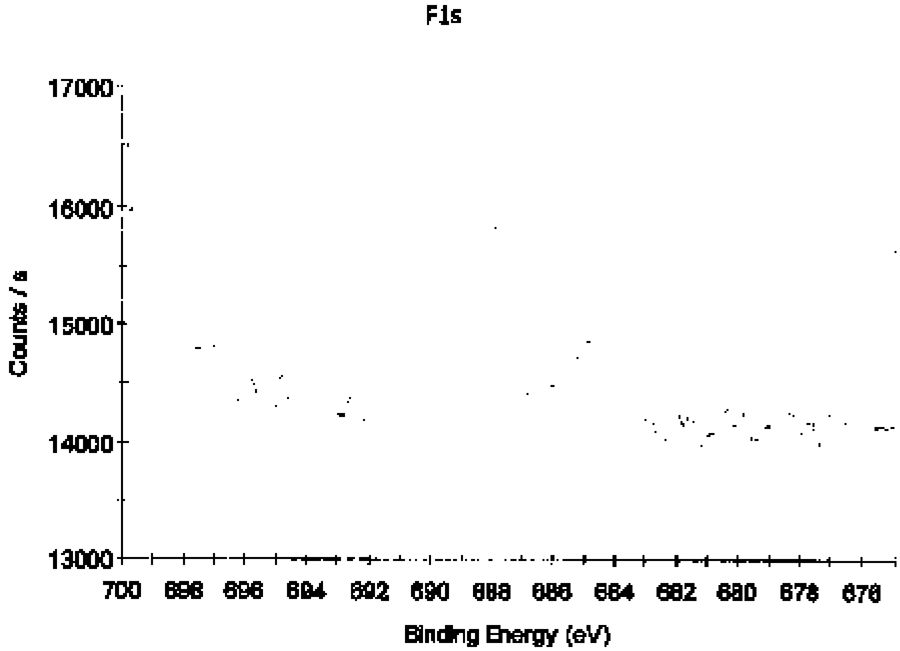

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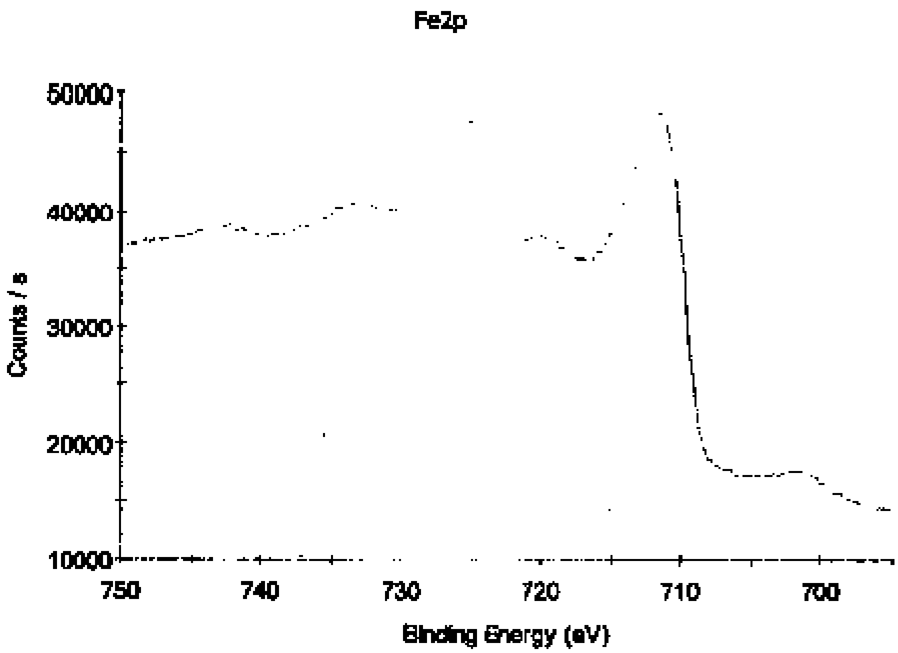

Figure 21

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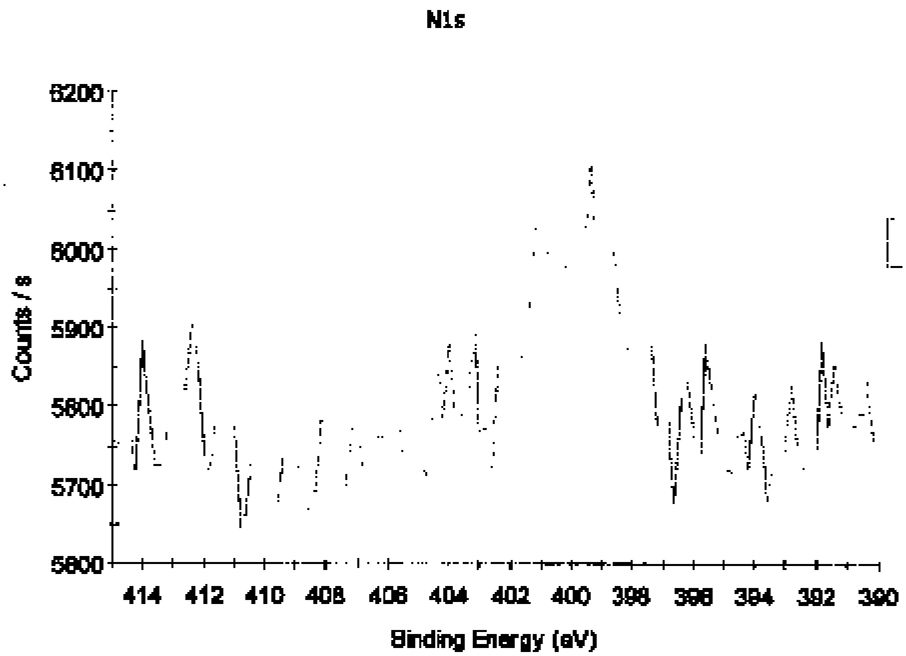

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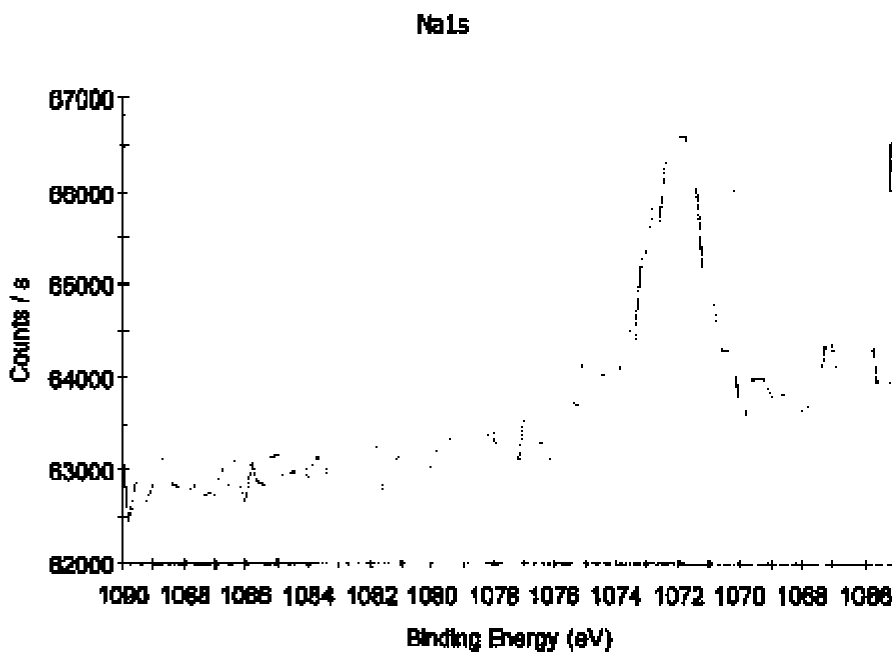

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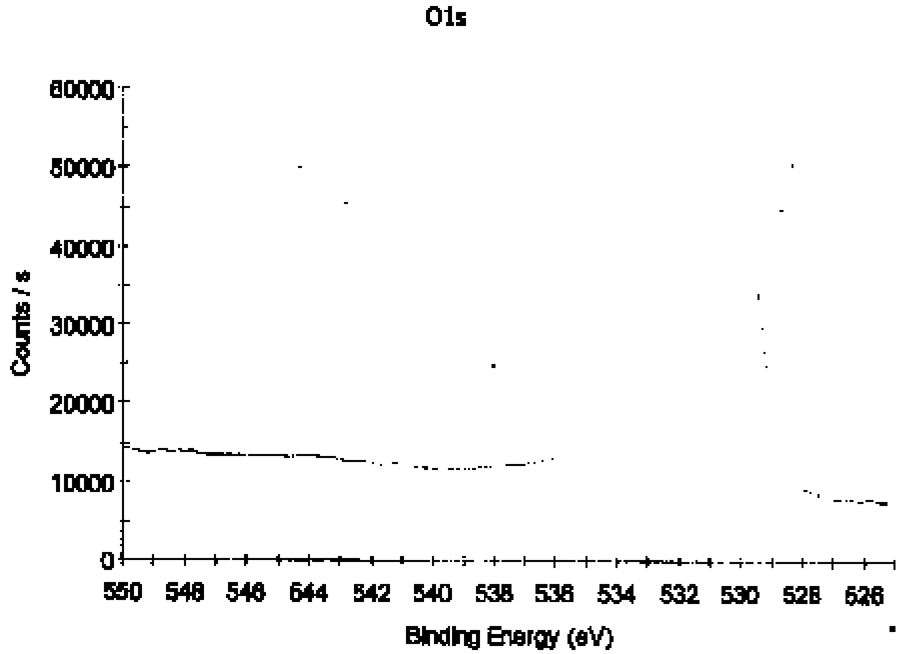

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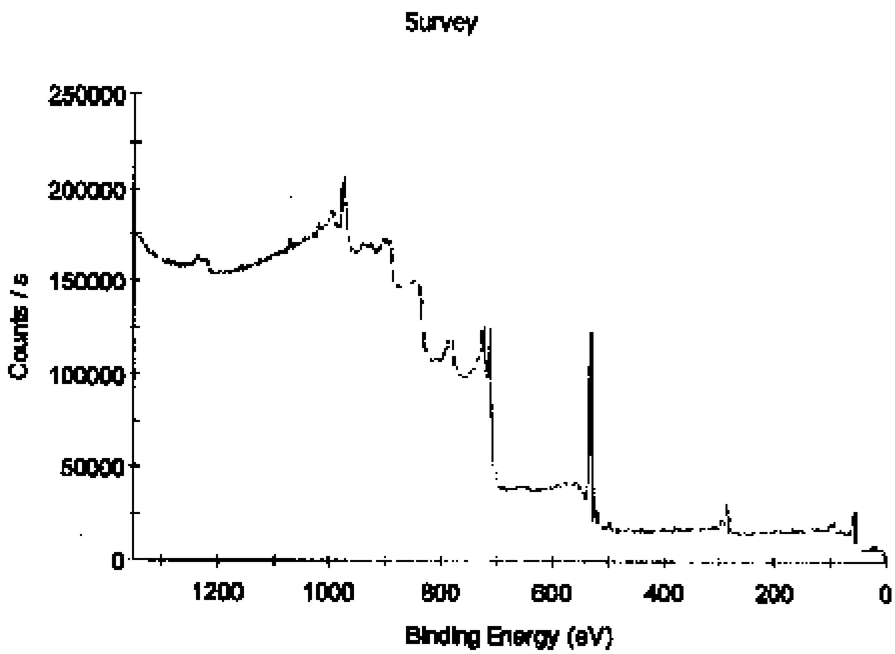

Figure 25

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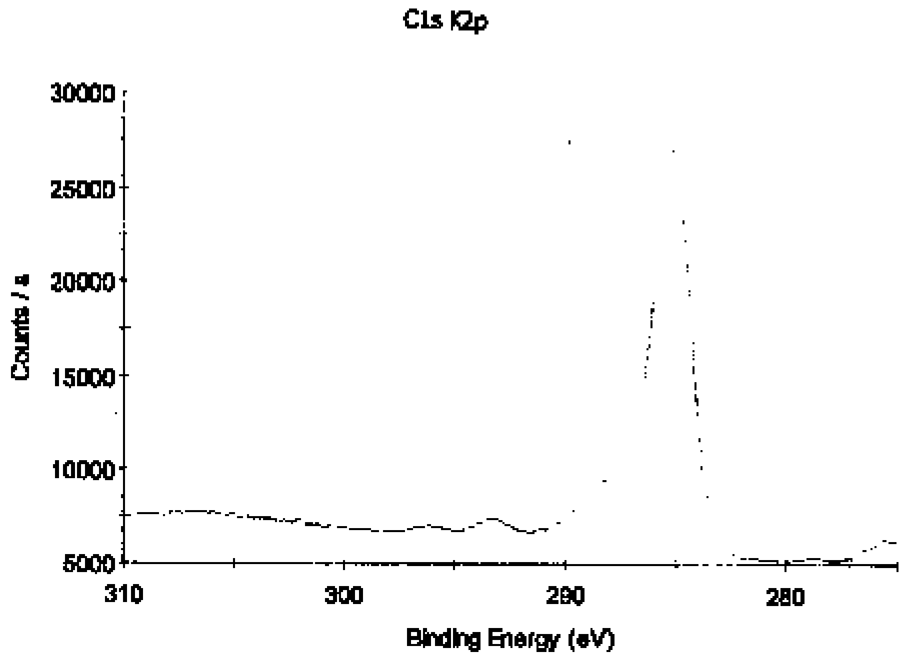
SKF04 Non-discoloured area on chamfer



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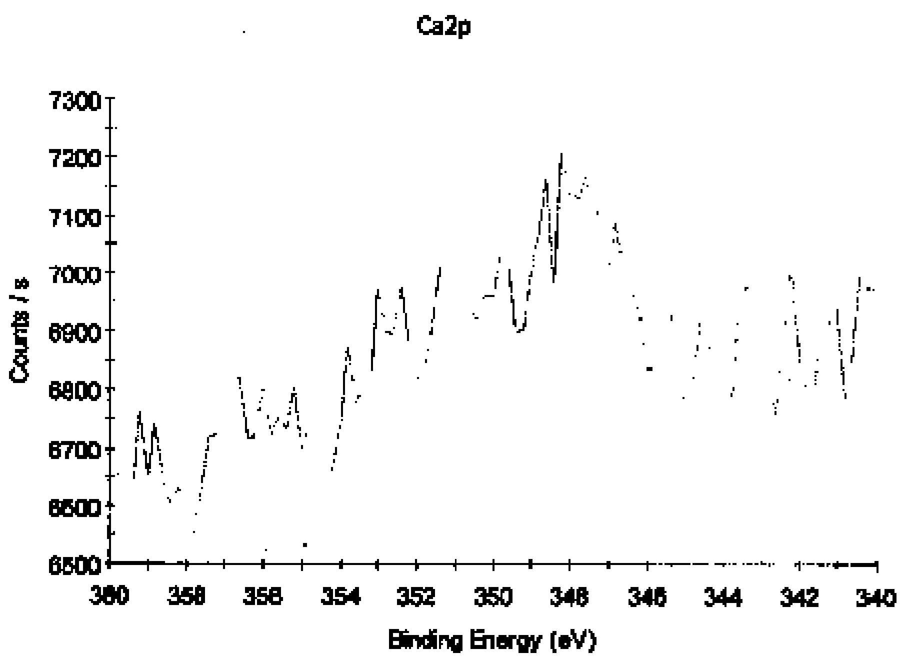

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SKF 001389

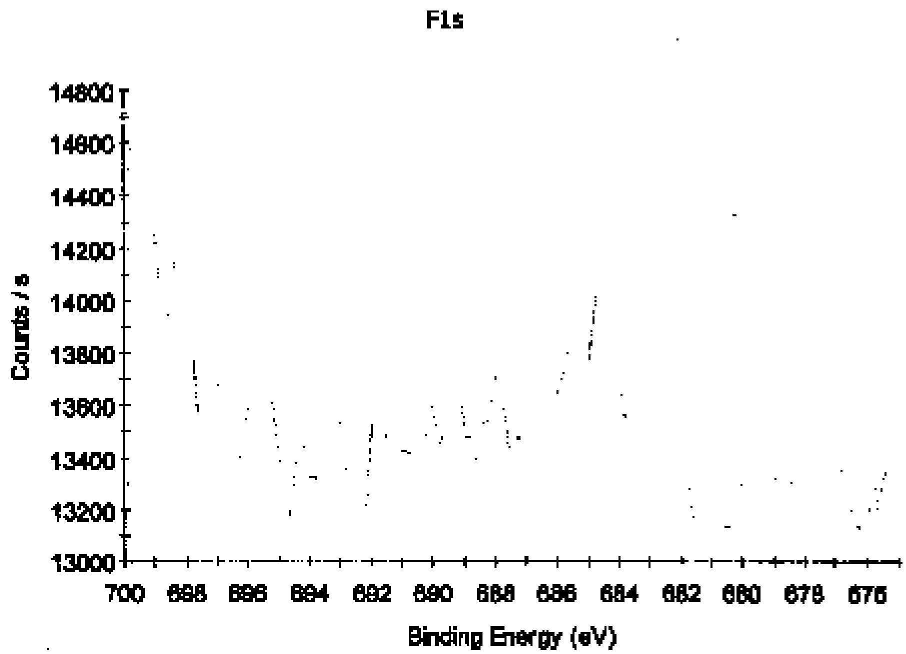

Figure 28

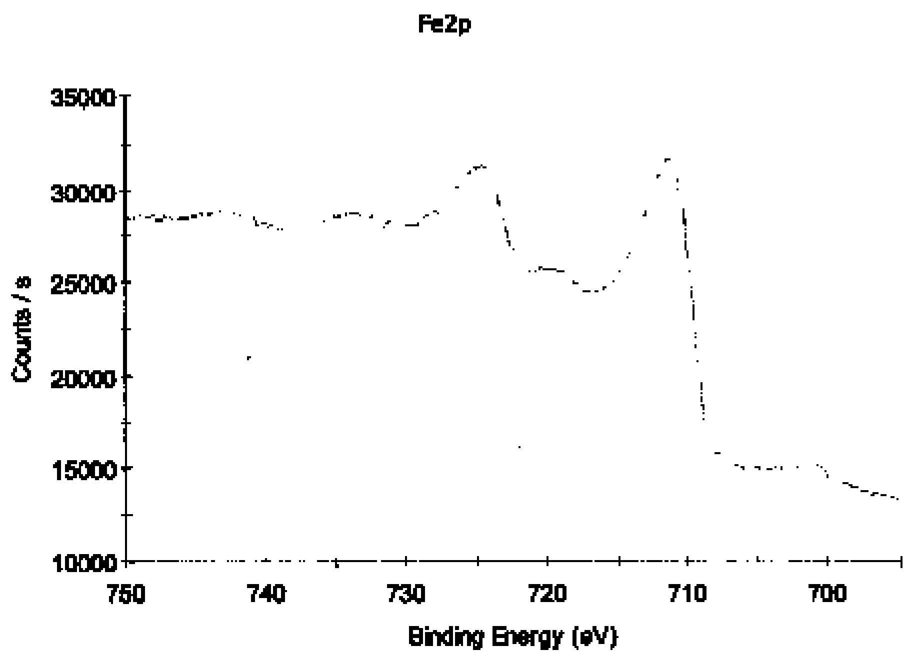

Figure 29

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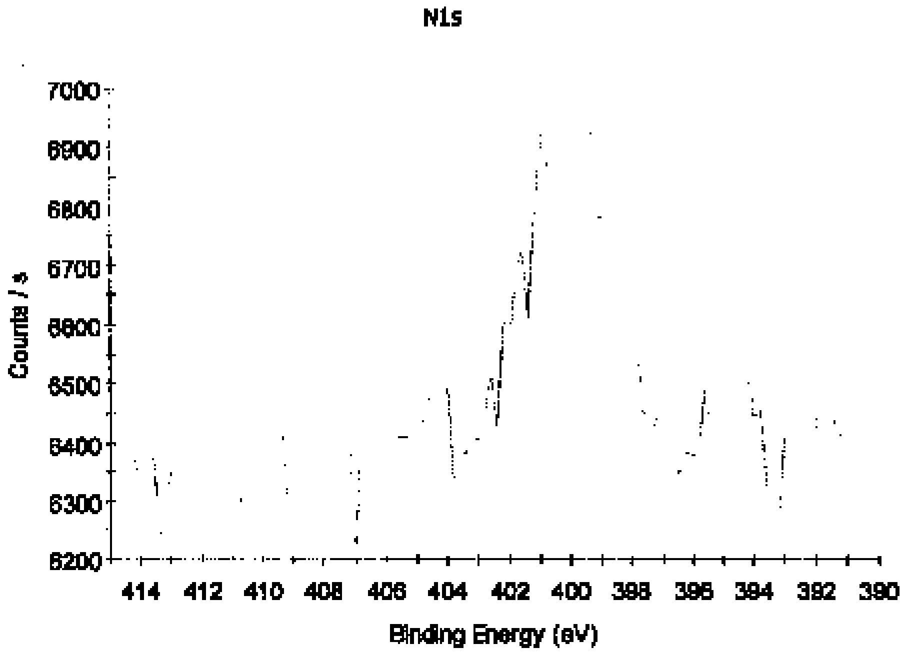


Figure 30

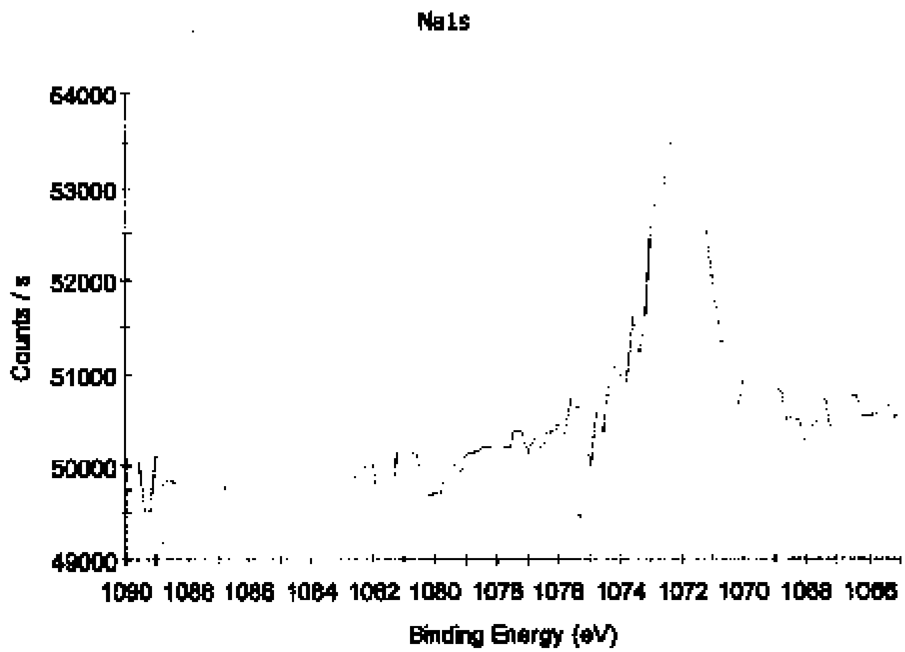
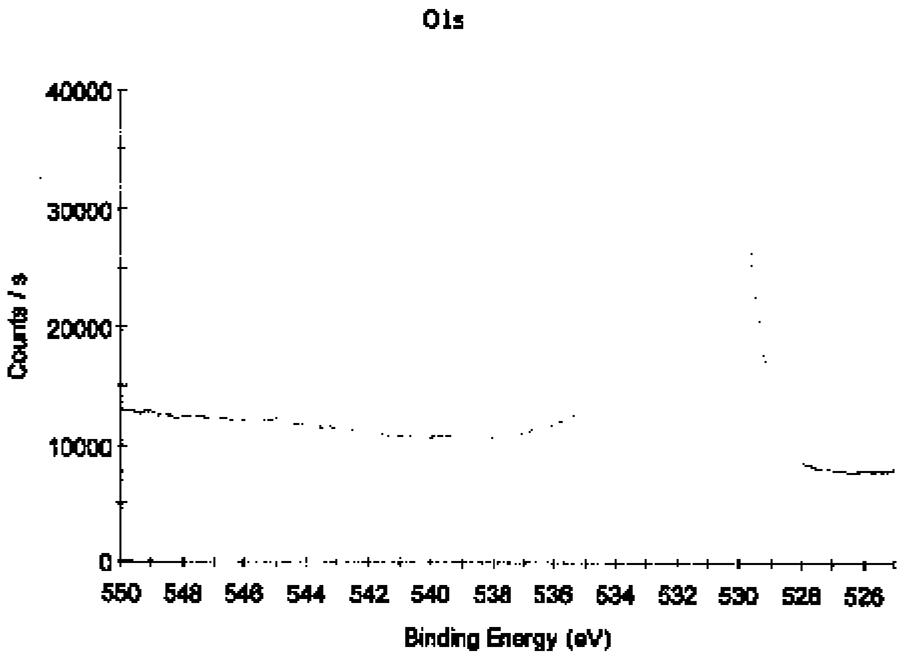


Figure 31

SKF 001371



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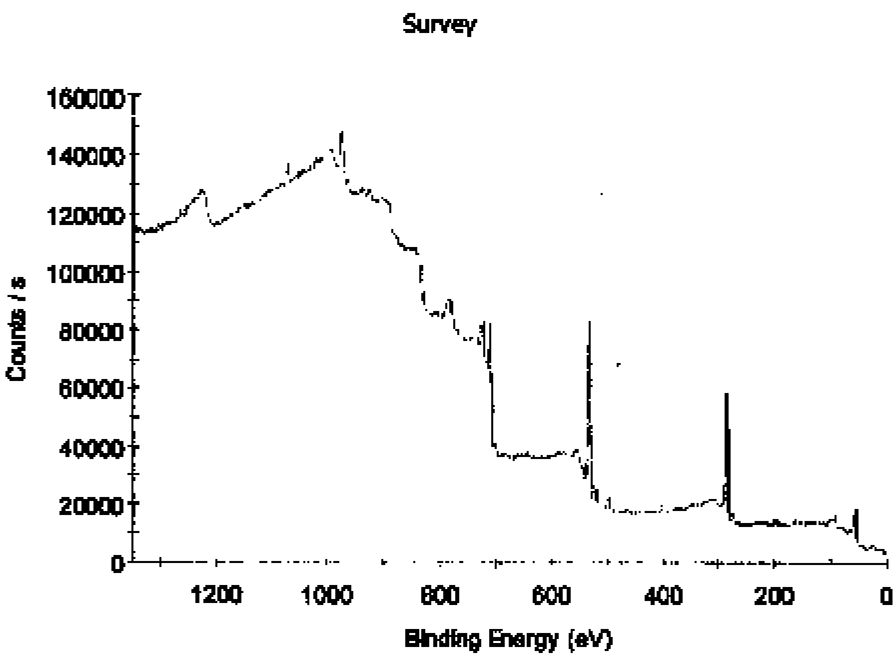

Figure 33

SKF 001372

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2002-07-10

ArvinMeritor THUs from the Field: X-Ray Analysis

Aidan Kerrigan

Materials Theory & Testing

EXTERNAL CUSTOMER
Interim Report on Project No. N02 184

ArvinMeritor THUs from the Field: X-Ray Analysis

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Key Words THUs, grade 3, 52100, grade 55, 1055M, through hardened, surface induction hardened, residual stress, line broadening, b/B ratio

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ArvinMeritor THUs from the Field: X-Ray Analysis

Abstract Three THUs were returned from the field after running for approximately 500,000 miles. The units had not failed. An x-ray investigation was performed on selected inner and outer ring raceways in order to determine the degree of material response to the application conditions.

Project background

Three THUs from the field were returned to SKF after running for approximately 500,000 miles. These have been investigated in ERC and reported here are the results of the x-ray investigation.

It should be noted that the THUs had not failed.

Objectives

To determine the fatigue status of the THUs after 500,000 miles in the application, using x-ray analysis.

Main results

See 'Main conclusions and recommendations'

Main conclusions and recommendations

The investigated inboard inner ring of unit 918279 did not show evidence of the accumulation of rolling contact fatigue damage to any significant extent at the centre of the raceway.

The inboard inner ring of unit 918287 showed evidence of a change in the residual stress profile in the raceway towards the edge of the overrolled track at the thinner end of the inner ring section due to running in the application. This change was in the form of the development of a compressive stress in the near surface region, which represents a material response to rolling contact fatigue. However, the line broadening parameter (b/B ratio) had a relatively high value, indicating only a limited accumulation of fatigue damage.

At the other measured positions of the inboard inner ring and all positions measured on the outboard inner ring of unit 918287, there was no evidence of significant material response to rolling contact fatigue.

The inboard raceway of the outer ring of unit 918287 gave an indication of surface fatigue, although the response was not as clear as that shown by the inboard inner ring (at the thinner end).

The outboard raceway of the outer ring of unit 918287 did not give an indication of a significant material response to rolling contact fatigue.

In summary, none of the THU components measured showed any evidence of the accumulation of sub-surface fatigue from the Hertzian stress induced by a rolling contact in the application.

Based on the residual stress profiles, there was evidence of a material response at the surface or near surface of the inboard inner ring raceway and the inboard outer ring raceway of unit 918287. In the absence of a sub-surface fatigue response, this would suggest that surface initiated fatigue would be the most likely failure mode. However, it is noted that the line broadening parameter (b/B ratio) remained at a relatively high value, indicating only a limited accumulation of fatigue damage at the surface or near surface region.

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1 Background

Four THUs were supplied to ERC for investigation. Three were returned from the field via the truck fleet operator Ryder and one unit was a new, unrun unit for baseline measurements. All units had been manufactured by SKF Aiken.

The three units from the field were marked and entered in to the ERC system as follows:

'Ryder Right Unit 918279'. The box was marked '596,184 miles' but the tag on the unit was marked '569,184 miles'. It was decided to use the mileage marked on the tag. All components of the unit were supplied, although the inner rings (IRs) were not marked as 'inboard' or 'outboard'. This unit was given the ERC code 02MR0020.

'Ryder Left Unit 317572'. This unit had covered 560,228 miles. The inboard inner ring (IR) was not supplied. This unit was given the ERC code 02MR0021.

'Ryder Left Unit 918287'. This unit had covered 591,711 miles. All components of the unit were supplied. This unit was given the ERC code 02MR0022.

The new, unrun unit was delivered complete and given the ERC code 02MR0019.

Based on the information supplied to the project team, coupled with the results of the visual inspection [Ref.1] and grease analysis [Ref.2], several investigations were performed on selected components. It should be stated that the three units returned from the field did not show any evidence of spalling fatigue on any of the raceways or cracking at the flanges.

Based on the observations of raceway damage and the position of the seal contact on the IR, it was determined which of the unmarked IRs supplied with unit 918279 was the inboard IR and which was the outboard IR.

A primary interest was to determine the material response to the rolling contact fatigue (RCF) conditions by x-ray diffraction. Prior to this, the raceway and other surfaces of the units were examined in the scanning electron microscope (SEM) [Ref.3].

2 Material Response Investigation

The investigation of material response to rolling contact fatigue (RCF) comprised of two components: determination of the residual stress profile and measurement of the change in line broadening of the diffraction lines.

Chromium (CrKα) radiation is used for the determination of the residual stress [Ref.4]. The calculated penetration depth of the radiation used was of the order of 10 µm. The residual stresses were determined by line shift analysis on the {211} martensite reflection using the $\sin^2\Psi$ method. The residual stresses are expressed in MPa.

The measured width of the {211} diffraction line in an unrun component depends on a number of factors, such as the amount of carbon in solid solution as a result of the hardening heat treatment. During RCF, the width of the {211} diffraction line can decrease, due to the accumulation of micro-plastic deformation i.e. fatigue. The measurement of the changes in the width of the {211} diffraction line is called 'line broadening', although it should be noted it is the decrease in the width (i.e. breadth) of the {211} diffraction line which is measured.

The changes in diffraction line broadening are expressed as the b/B ratio, with 'b' being the diffraction line-broadening as measured at the location of interest and 'B' being the diffraction line-broadening as measured in the unrun component (the unaffected region) at equal depth positions. For this reason, the unrun unit was measured as a baseline. For the through hardened IRs, only one baseline measurement was required. However, for the induction hardened outer ring (OR) raceways, both the inboard and outboard raceways were measured.

In order to illustrate the information which can be obtained from x-ray analysis, two examples are shown from previous investigations in figures 1 and 2.

Figure 1 shows the residual stress profile and b/B profile for the IR of a tested, but unfailed, taper roller bearing (TRB). In the unrun condition, the IR has a high compressive stress at the surface (depth = zero) which is typical and due to the hard machining operations performed after hardening. The residual stress becomes tensile at a depth of 10 µm, which would be expected in a martensitically through hardened ring. At deeper depths, the profile is basically neutral. After testing, it can be seen that a compressive residual stress of relatively high magnitude has been developed at a depth of approximately 100 µm, which was the depth of maximum shear stress (z_o). It can also be seen that the b/B profile also reduces below the surface in a similar way to the residual stress profile. Both the residual stress profile and b/B profile indicate a clear material response to the sub-surface Hertzian stress experienced by the IR due to RCF and it would be anticipated that this IR would fail by sub-surface initiated spalling.

Figure 2 shows a separate case, also for a TRB IR, but tested under different conditions. In the unrun condition, the IR has the expected residual stress profile of a martensitically through hardened bearing component. After testing, it can be seen that a compressive residual stress has developed at the surface at depths between 10 µm and 50 µm with a small dip at 75 µm. The b/B profile also shows decreasing values from a depth of 50 µm up to the surface. In this case, it is the surface or near surface region which is showing a material response to the RCF conditions and it would be anticipated that surface initiated spalling would be the failure mode. It should be noted that at 75 µm, there is a material response in that the residual stress profile shows a small dip but the b/B value at this depth is at 1.0, indicating that no significant fatigue response was evident at this depth.

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It should be noted that the quoted accuracy of a residual stress measurement is ± 50 MPa and this should be taken into account when drawing conclusions about differences between unrun and run bearing components.

As a guideline, when the b/B ratio reaches a level of 0.90 or lower, this is taken as an indication of changes in the microstructure due to fatigue.

It can be seen in figures 1 and 2 that the magnitude of the changes in the residual stress and b/B ratio in these unfailed components is sufficient to clearly indicate sub-surface fatigue (figure 1) and surface, or near surface, fatigue (figure 2). Also, further decreases in the residual stress profile and b/B ratio, in the region of fatigue, would be anticipated before a fatigue failure occurred in either component.

The results of the x-ray investigations can be seen in figure 3 and figures 5 to 14. It should be noted that the depth of maximum shear stress (z_o) has been stated to be 0.135 mm if the truck is driving straight ahead and 0.206 mm for cornering with 0.15g. For the IRs, the circumferential position of the measurement was taken as the highest loaded zone, as could be observed by the marks from running.

Figure 3 shows the residual stress profile of the unrun IR, which was used as a baseline for all IR measurements. The profile has a high compressive stress at the surface (depth = zero) which is typical and due to the hard machining operations performed after hardening. The residual stress becomes tensile at a depth of 10 μm, which would be expected in a martensitically through hardened ring. At deeper depths, the profile is basically neutral. Figure 3 also shows the residual stress profile of the inboard IR of unit 918279 and it should be noted that this profile was measured in the centre of the raceway. There is a compressive stress at the surface and the remainder of the profile basically follows the unrun profile, with some deviation, either due to the application conditions or the accuracy of the measurement (± 50 MPa). This figure also shows the 'b/B' ratio, which is a comparison of the line broadening of the IR of unit 918279 used in the application with the unrun IR. It can be seen that the b/B ratio is relatively high, never dropping below 0.95. By definition, the b/B ratio has a maximum value of 1.0 and the profile shown in figure 3 would indicate that very little fatigue damage can be observed in the centre of the inboard IR from unit 918279.

Unit 918279 had run for 569,184 miles. It was decided to investigate the longest running unit i.e. 918287 which had run for 591,711 miles. As a further refinement, it was decided to measure the profiles in three positions on the raceway, as illustrated in figure 4. For the IRs, measured in the highest loaded zone, Position 2 was the centre of the raceway (13 mm), Position 1 was at the thicker section (13 mm + 6 mm) and Position 3 was at the thinner section (13 mm - 6 mm). For the ORs, the same three positions were measured, with Position 2 at the centre of the raceway (13 mm), Position 1 at the thicker section (13 mm + 6 mm) and Position 3 at the 'thinner' section (13 mm - 6 mm). For the inboard OR raceway, the section can be said to be thicker or thinner but this is less clear for the outboard OR raceway. For the unrun components, the baseline residual stress measurement was made at the centre of the raceway i.e. Position 2.

The residual stress profiles and b/B ratio of the inboard IR are shown in figures 5 and 6 with the equivalent results for the outboard IR shown in figures 7 and 8. As before, the results were compared with the profile from the unrun IR. Figure 5 shows evidence of material response in the near surface region. This was evident in Position 3 and can be seen by the generation of a compressive stress at depths to around 75 μm. The generation of compressive stresses at the near surface in Position 3 indicates some material response in this region but the high values of b/B (>0.9) in figure 6 show that there was only a limited accumulation of fatigue. At deeper depths on all three profiles, and as shown by the b/B ratio in 6, there is no evidence of a response to the sub-surface Hertzian contact stress and, hence, no indication of classic sub-surface RCF failure in this unit. Figures 7 and 8 for the outboard IR of this unit do not indicate any evidence of the accumulation of either surface or sub-surface fatigue as the profiles do not differ significantly from the unrun IR and the b/B ratio remains at a high level i.e. above 0.90.

The baseline measurements for the OR raceways of new, unrun unit are shown in figures 9 and 10. In figure 9, it can be seen that the inboard raceway has a high compressive stress at the surface (depth = zero) due to the hardmachining processes. At deeper depths, the residual stress is compressive, as would be expected in a surface induction hardened component, and the stress has a magnitude of 300 to 350 MPa. For the outboard raceway, the residual stress profile, figure 10, has the same characteristics as that of the inboard raceway except that the magnitude of the compressive stress in the induction hardened surface shows more variation and tends to have a lower value. This difference in residual stress is likely to stem from slight differences in the induction hardening and tempering process. This is also indicated by the line broadening measurements, which also show a slight difference. The inboard raceway had a line broadening value of approximately 7.5 while the outboard raceway had a value of approximately 8.0.

The residual stress profiles and b/B profiles for the inboard and outboard raceways of the OR of unit 918287 are shown in figures 11 to 14.

Figure 11 shows the residual stress profiles in the three positions on the inboard raceway. The magnitude of the compressive stress at the surface (depth = zero) is slightly lower than that measured in the unrun unit. At the second measurement position, at a depth of 10 μm, all three profiles show a slightly higher magnitude of compressive stress as compared to the new, unrun unit at the same depth. This would indicate some material response in this region but the relatively high values of b/B, in figure 12, show that there was only a limited accumulation of fatigue damage. At deeper depths, the profiles do not show any strong features, with compressive stresses of the order of 250 to 300 MPa. The b/B profiles for the inboard raceway are shown in figure 12 and these indicate only a limited response to RCF as the values tend to be high, lying between 0.90 and 1.0. It is noted that the lowest b/B values are at the surface.

The residual stress and b/B profiles for the outboard raceway of the OR of unit 918287 are shown in figures 13 and 14. As in the new, unrun unit it can be seen that the magnitude of compressive stress tends to be lower in the outboard raceway as compared to the inboard raceway. The residual stress profiles do not indicate a strong response to RCF, although the variation in the baseline residual stress profile makes it difficult to compare. It is noted that the b/B profiles in the three positions, figure 14 tend to have values above 0.90 i.e. only a limited accumulation of fatigue.

3 Materials Response Conclusions

The investigated inboard inner ring of unit 918279 did not show evidence of the accumulation of rolling contact fatigue damage to any significant extent at the centre of the raceway.

The inboard inner ring of unit 918287 showed evidence of a change in the residual stress profile in the raceway towards the edge of the overrolled track at the thinner end of the inner ring section due to running in the application. This change was in the form of the development of a compressive stress in the near surface region, which represents a material response to rolling contact fatigue. However, the line broadening parameter (b/B ratio) had a relatively high value, indicating only a limited accumulation of fatigue damage.

At the other measured positions of the inboard inner ring and all positions measured on the outboard inner ring of unit 918287, there was no evidence of significant material response to rolling contact fatigue.

The inboard raceway of the outer ring of unit 918287 gave an indication of surface fatigue, although the response was not as clear as that shown by the inboard inner ring (at the thinner end).

The outboard raceway of the outer ring of unit 918287 did not give an indication of a significant material response to rolling contact fatigue.

In summary, none of the THU components measured showed any evidence of the accumulation of sub-surface fatigue from the Hertzian stress induced by a rolling contact in the application.

Based on the residual stress profiles, there was evidence of a material response at the surface or near surface of the inboard inner ring raceway and the inboard outer ring raceway of unit 918287. In the absence of a sub-surface fatigue response, this would suggest that surface initiated fatigue would be the most likely failure mode. However, it is noted that the line broadening parameter (b/B ratio) remained at a relatively high value, indicating only a limited accumulation of fatigue damage at the surface or near surface region.

4 References

Ref.1 G. de Wit, ERC report NL02T903e, 'ArvinMeritor THUs from the Field: Visual Inspection'

Ref.2 A. Kerrigan, ERC report NL02M902e, 'ArvinMeritor THUs from the Field: Grease Analysis'

Ref.3 A. Kerrigan, ERC report NL02M903e, 'ArvinMeritor THUs from the Field: Scanning Electron Microscopy'

Ref.4 'Residual Stress Measurement by X-Ray Diffraction - SAE J784a', Second Edition, Society of Automotive Engineers, Inc., Two Pennsylvania Plaza, N.Y., N.Y. 10001, USA. 1971

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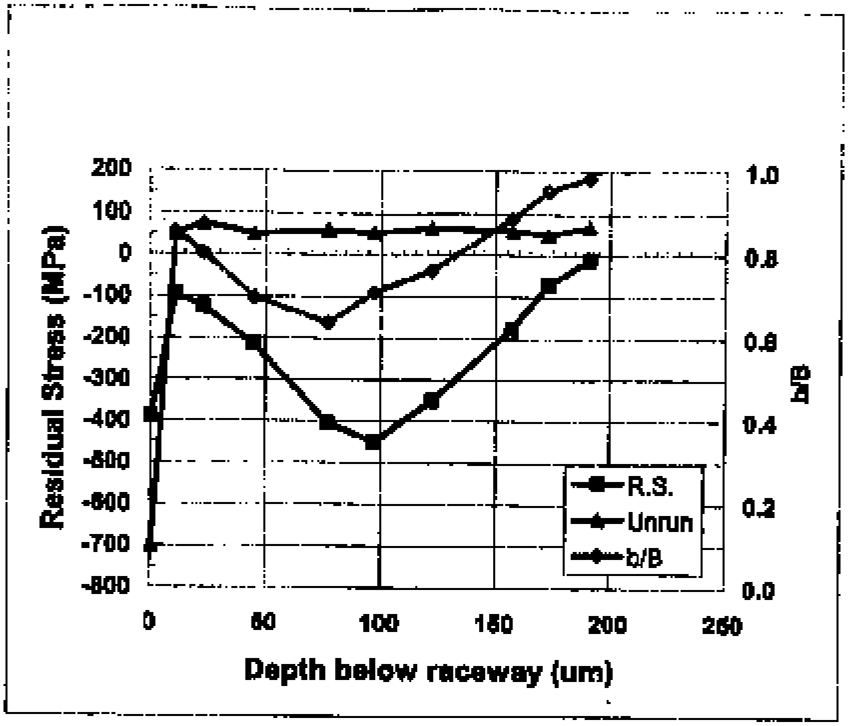
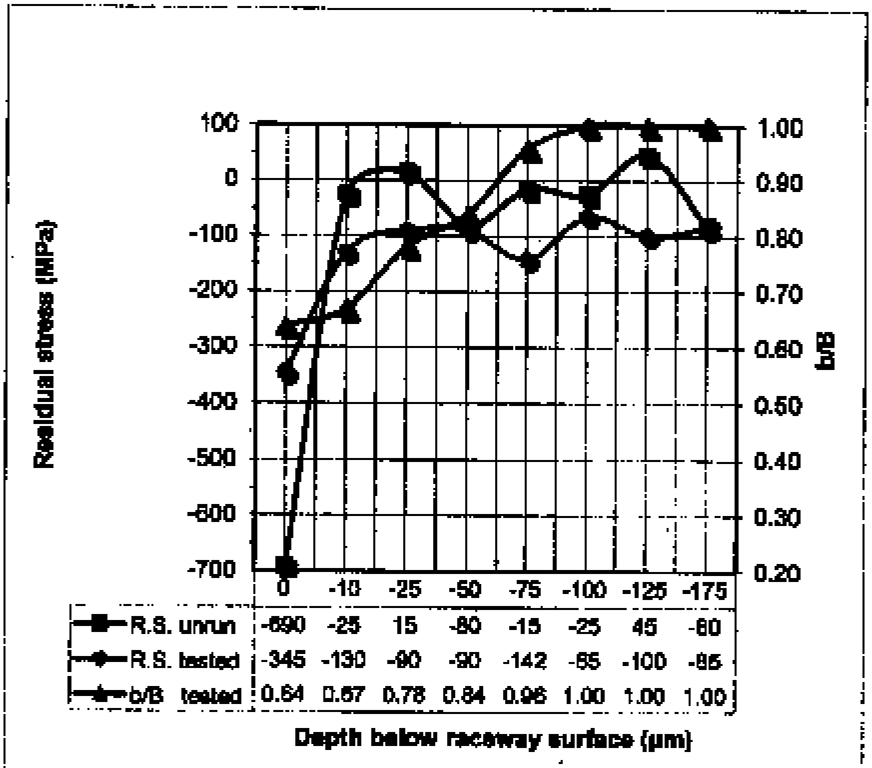


Figure 1. Example from previous investigation. "R.S." = Residual Stress of tested bearing (R



	0	-10	-25	-50	-75	-100	-125	-175
R.S. unrun	-690	-25	15	-80	-15	-25	45	-80
R.S. tested	-345	-130	-90	-90	-142	-65	-100	-85
b/B tested	0.64	0.67	0.78	0.84	0.96	1.00	1.00	1.00

Figure 2. Example from previous investigation.

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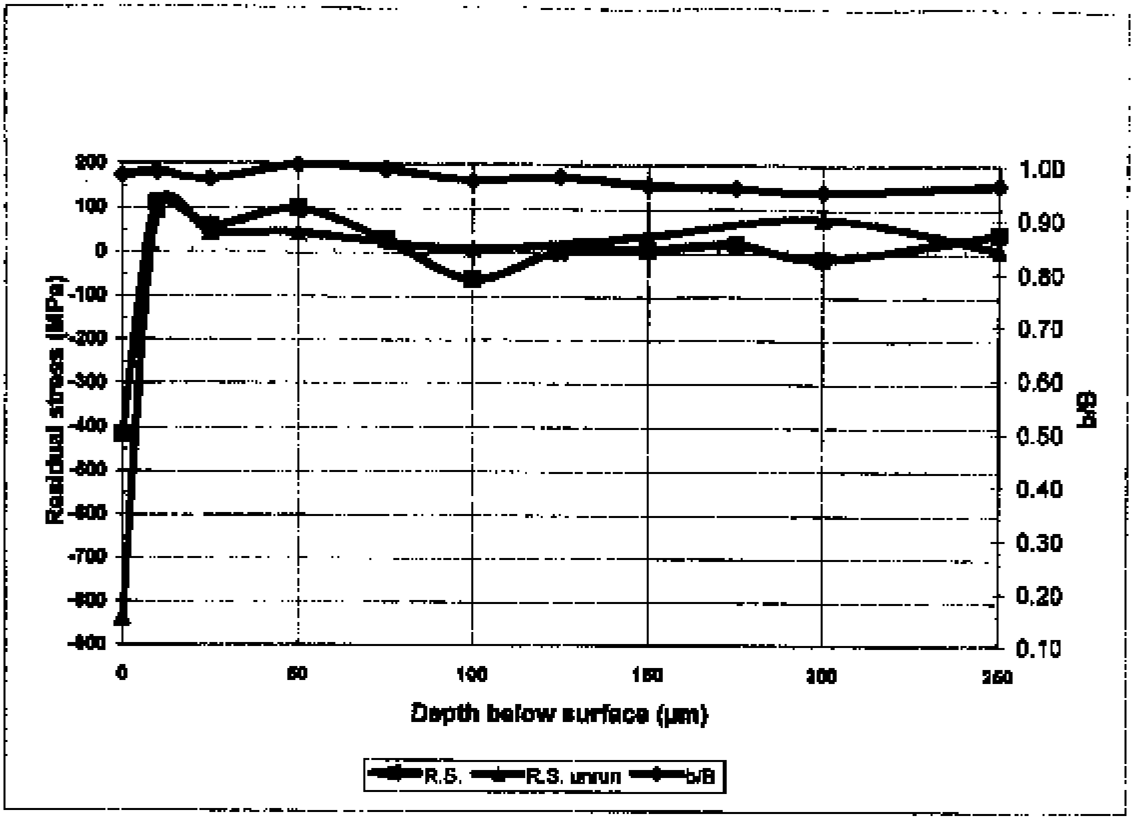

Figure 3. Inboard IR of unit 916276

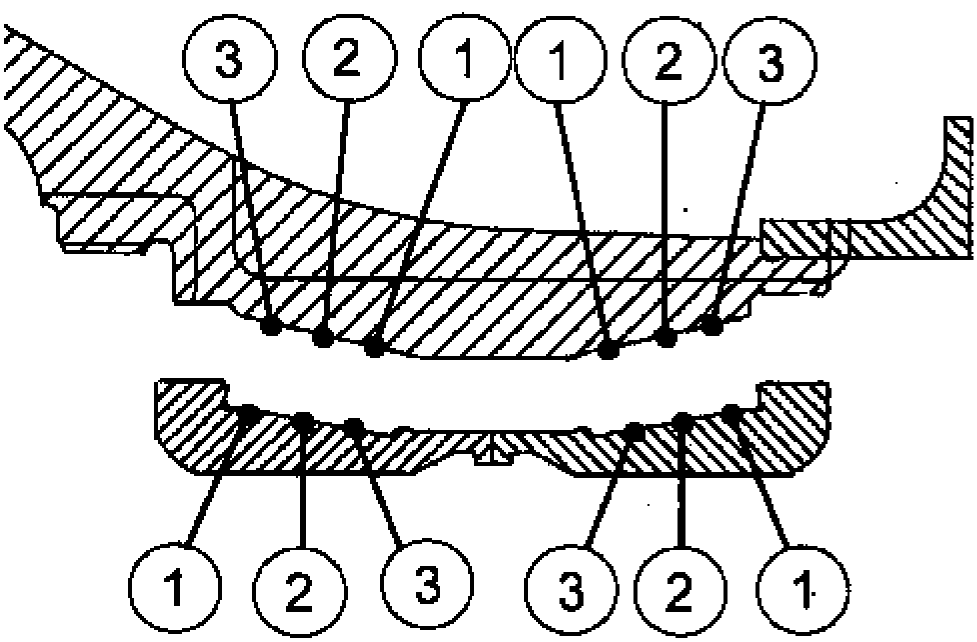

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Figure 4. Indication of the measurement positions in the x-ray analysis investigation

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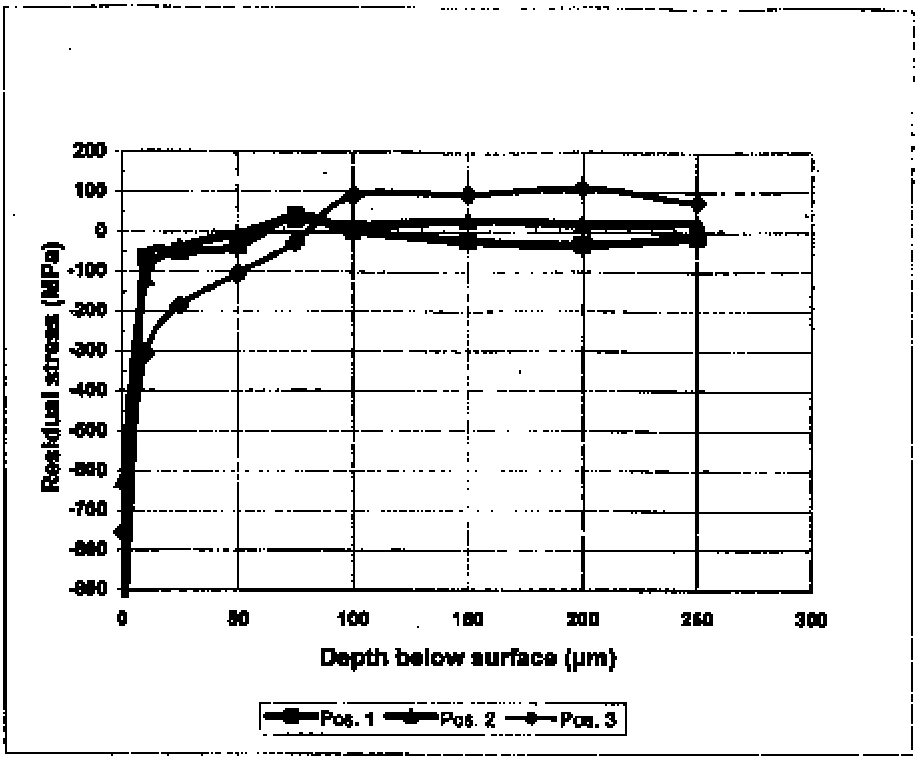

Figure 5. Inboard IR of unit 918287

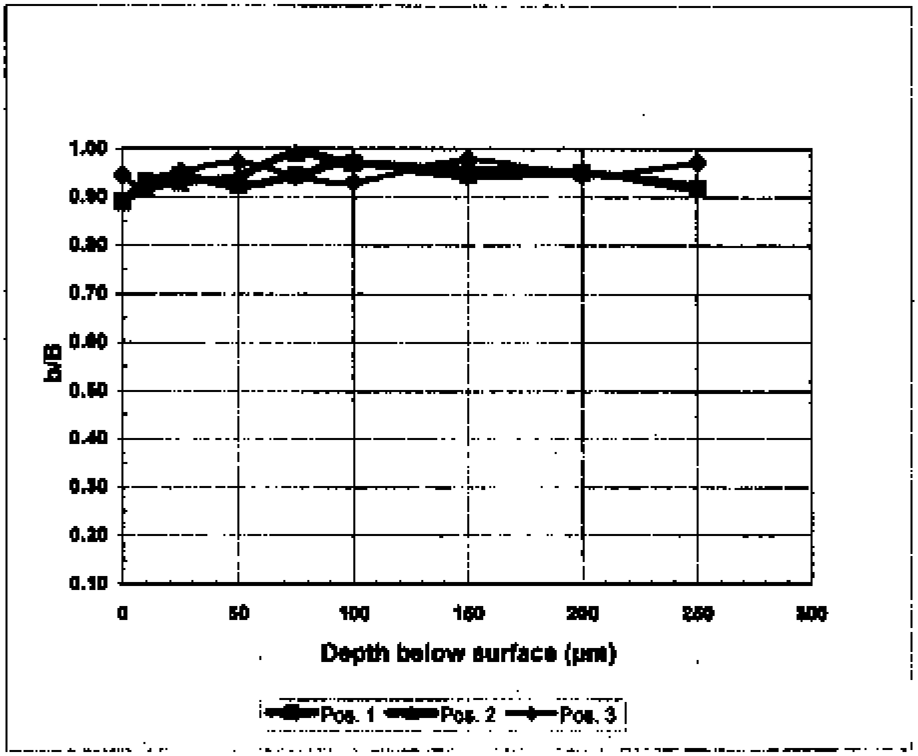

Figure 6. Inboard IR of unit 918287

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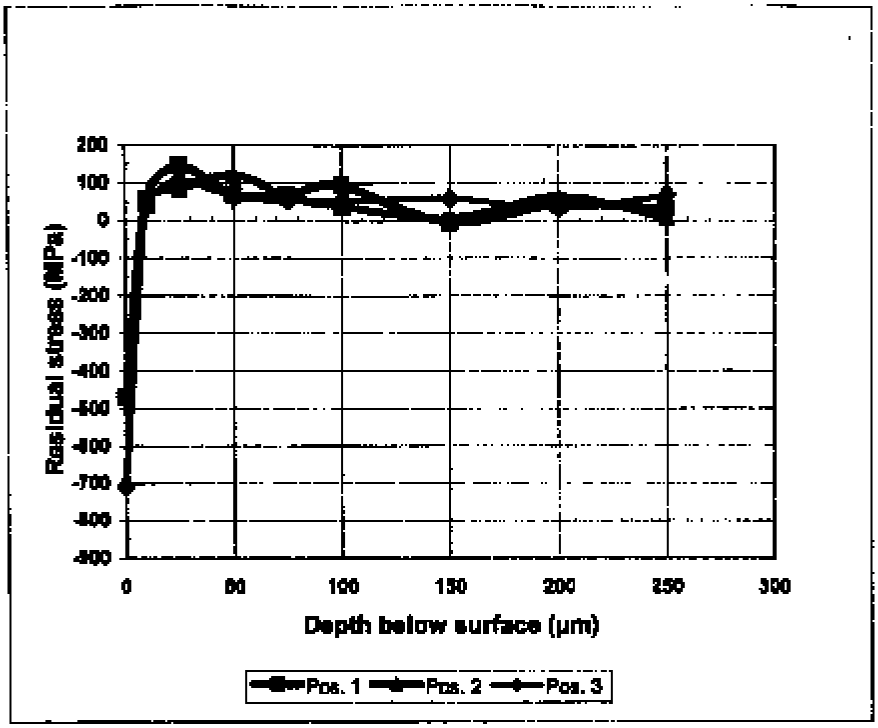

Figure 7. Outboard IR of unit 918287

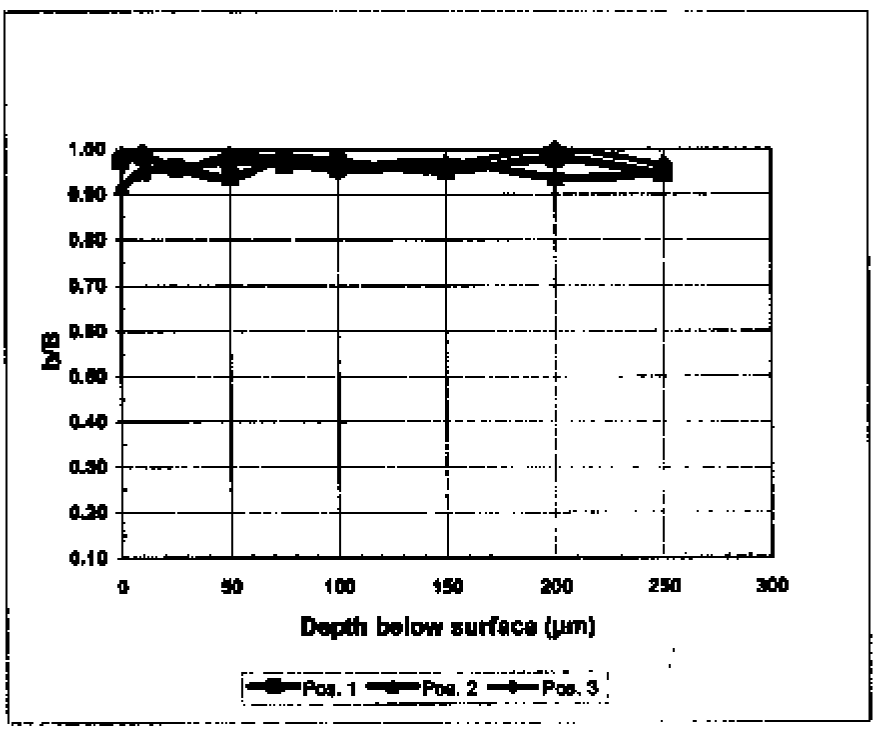

Figure 8. Outboard IR of unit 918287

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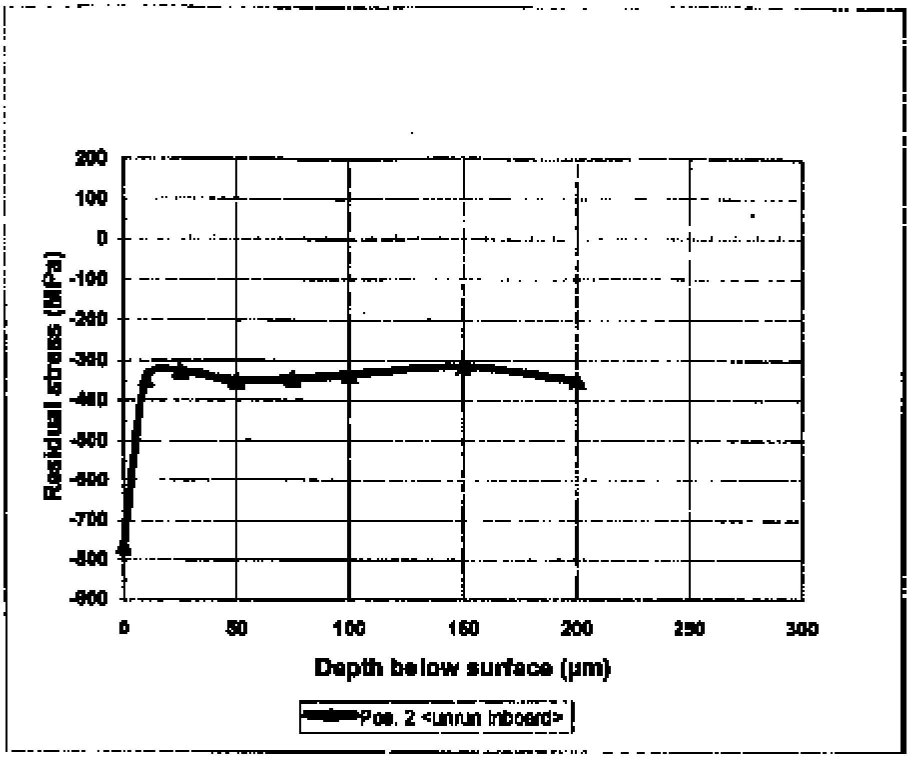

Figure 9. Inboard raceway of OR of new, unrun THU (02MR0019)

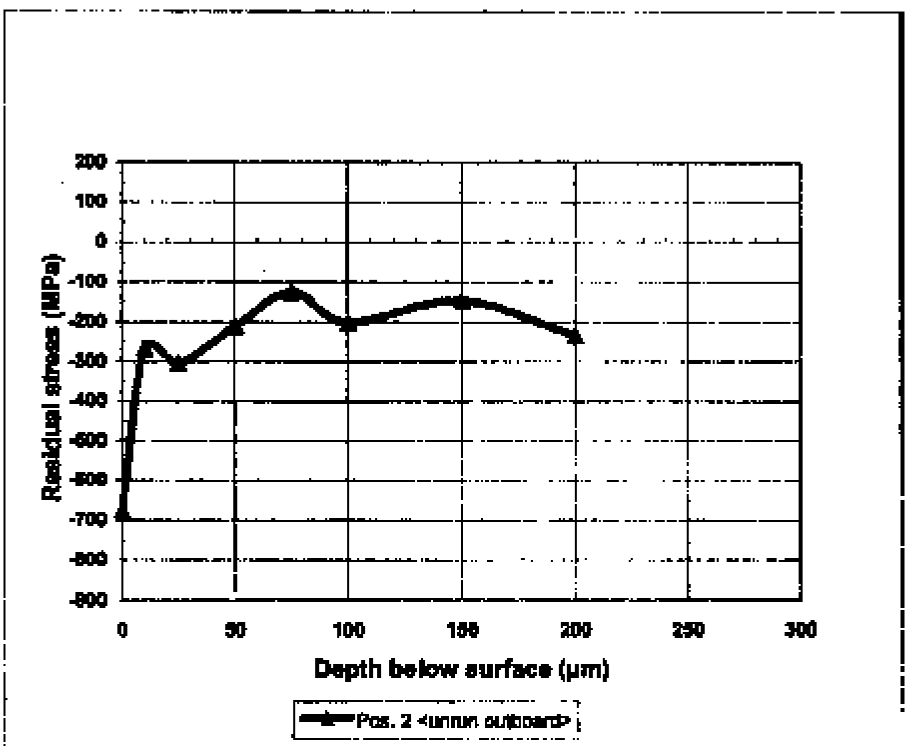

Figure 10. Outboard raceway of OR of new, unrun THU (02MR0019)

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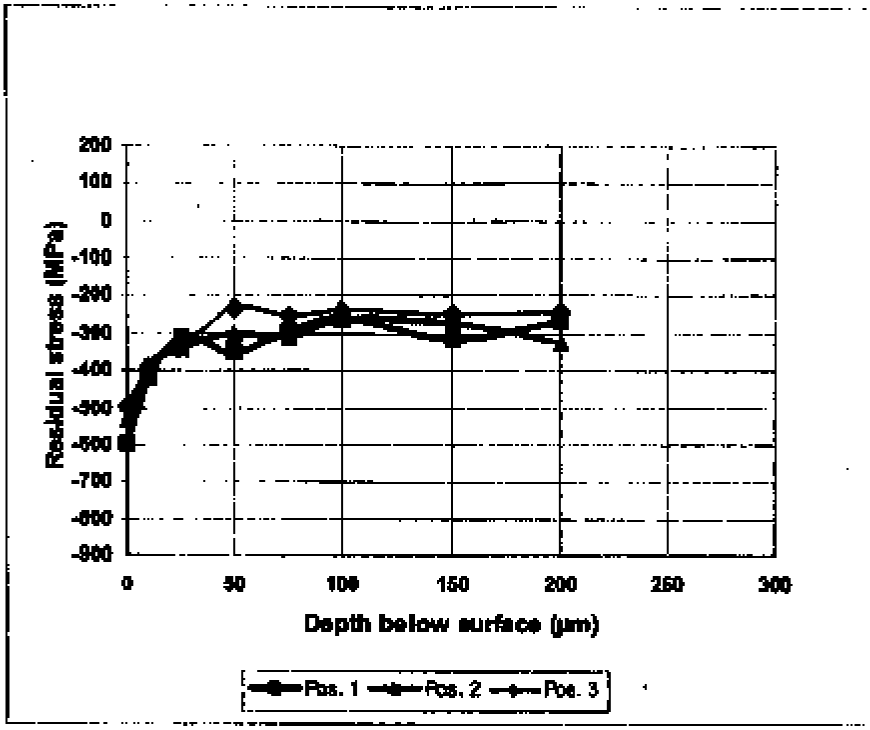

Figure 11. Inboard raceway of OR of unit 918287

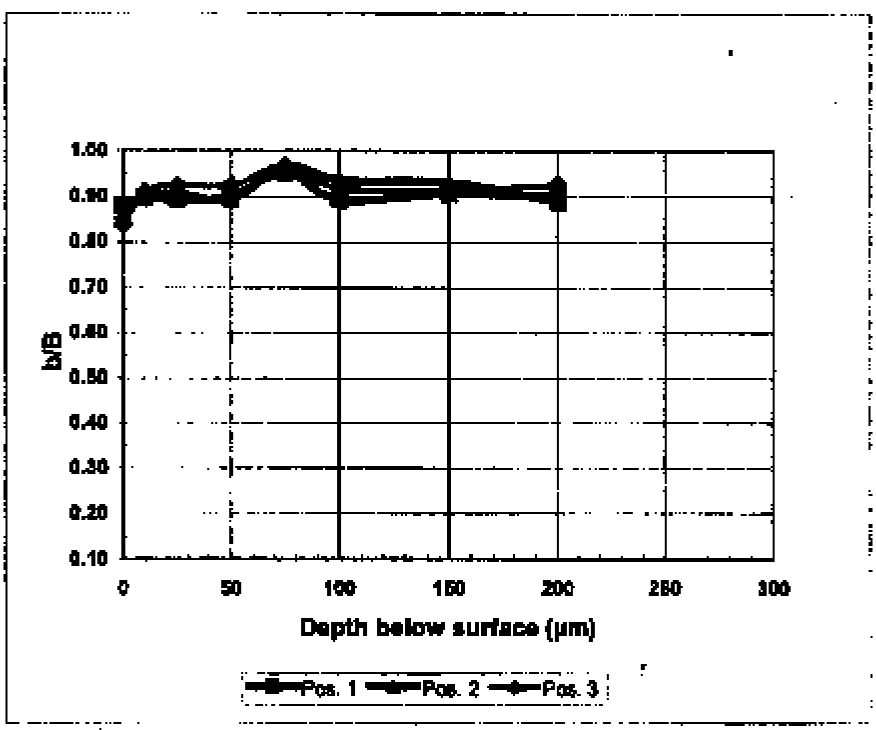

Figure 12. Inboard raceway of OR of unit 918287

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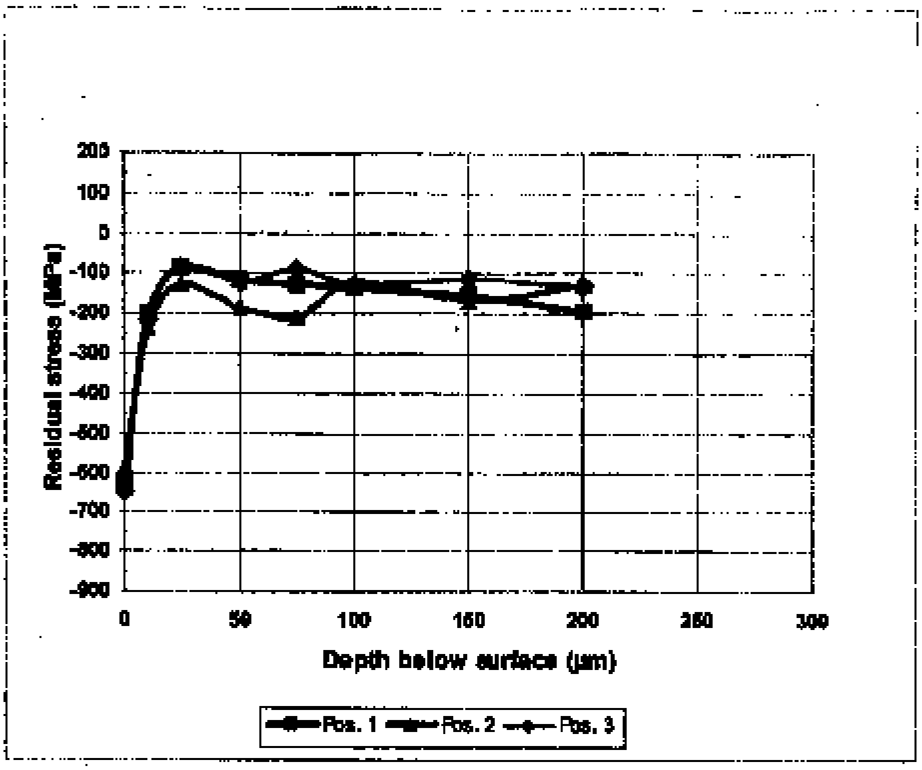

Figure 13. Outboard raceway of OR of unit 918287

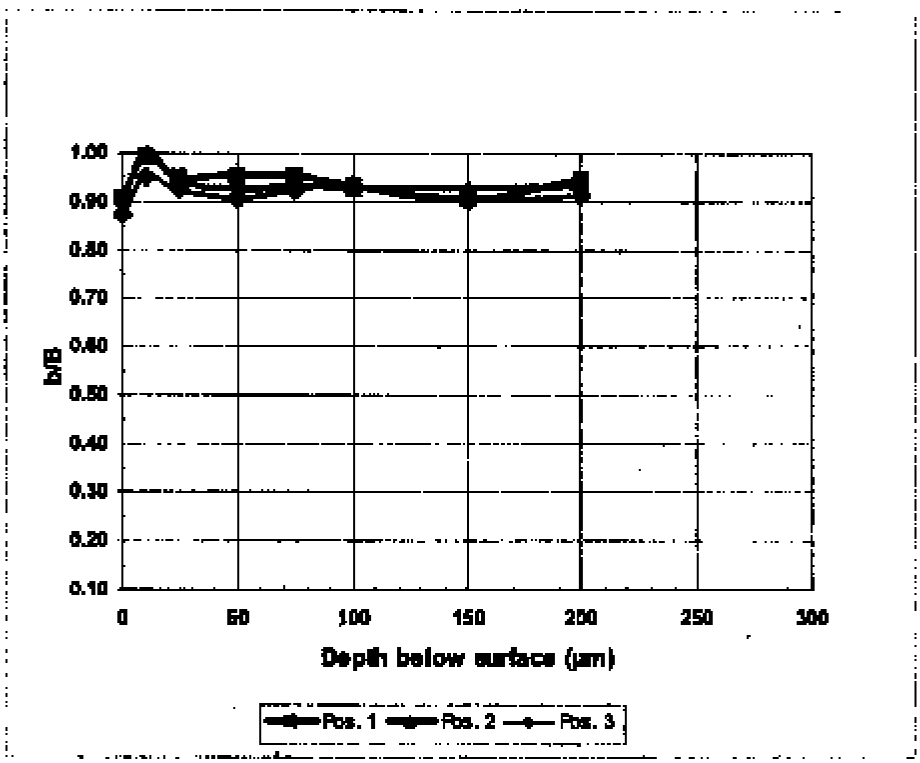

Figure 14. Outboard raceway of OR of unit 918287

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Meritor THUs from the Field: Visual Inspection.

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Materials Theory & Testing

EXTERNAL CUSTOMER
Interim Report on Project No. N02184

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Meritor THUs from the Field: Visual Inspection.

Abstract There have been incidents with THUs in the USA. Three run units, taken from the field, were supplied to ERC for investigation. This visual inspection showed that the bearings had run under poor lubrication conditions. The reason for this is most likely ingress of water in the bearings. It has been defined what further investigations are needed to deliver the proof for a more definite and complete root cause for the failures.

Project background

There have been incidents with THUs in the USA. Three run units, taken from the field, have been supplied to ERC for investigation and modelling. A visit to SKF Schweinfurt was made to inspect other unfailed as well as failed THUs. A remarkable fact is that the same type of THUs are functioning well here in Europe.

Objectives

To visually inspect the THUs received from the field and to define further investigations.

Main results

The three THUs delivered to ERC had not failed and could still have been used in the field. These THUs were in the ideal condition for a determination of the applied running conditions. These showed to have been tough for the bearings in term of the lubrication conditions, most likely caused by water ingress.

The unfailed THUs in Schweinfurt showed a very similar appearance as the three THUs at ERC.

The failed THUs in Schweinfurt showed the logical result of what would happen to the unfailed bearings if they had been used longer.

The detailed results of the visual inspection are shown on the following pages of this report.

Main conclusions and recommendations

Some of the conclusions are only indicative, i.e. further investigations, microscopy with higher magnification (SEM), grease analysis and X-ray analysis, are needed for confirmation and/or determination of the potential root cause for failure. Bearing this in mind the following route cause for failure is suggested as the most likely:

1. The application conditions for the THUs were not ideal.

1.a. Loose fit on the shaft, resulting in fretting corrosion in the bore of the inner rings.

1.b. High bending forces on the knuckle and/or shaft, resulting in fretting corrosion on both side-faces of the inner rings.

1.c. Poor surface finishing of the knuckle surface in contact with the inner ring (in-board) had an accelerating effect on the formation of fretting corrosion.

The recommended investigations are ongoing and are required for the confirmation of the following.

2. Water entering in to the THU in the bore/shaft position.

2.a. Resulting in found moisture corrosion.

2.b. Water entered also in to the grease, resulting in poor lubrication conditions, i.e. thin film.

3. The surface initiated spalling, as observed in eight THUs in Schweinfurt, was caused by poor lubrication resulting in adhesive wear, smearing and surface distress.

4. Modelling of the loading conditions could explain if these might have contributed to a (temporary) negative effect, e.g. during braking, on the lubrication conditions and therefore have had an accelerating effect on the failure process.

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visual inspection.

following abbreviations are used:
out-board,
, OR = outer ring.

ence of a ring is 360 ° with the loaded
Rs.

visual inspection of THUs in
ed here as well and written in a
rity.

failed, were delivered to ERC for
s and some additional information
n table 1.

R	Miles	Remarks
F	596.184	596.___ miles was noticed elsewhere in the delivered documents.
	591.711	
	560.228	

ree bearings some unfailed (7 THUs,
e 2, were inspected in Schweinfurt.

Miles	*Remarks (by Ryder)*
484.508	*One OB ring had stain starting to flake, some OB ring signs of creeping.*
484.508	
494.508	
484.508	
466.773	*Good condition*
466.773	
615.973	*Inner cones sign of creeping.*
615.973	
615.973	*Inner cones creeping*
615.973	
581.925	*Heavy fretting in bore.*
581.925	
543.562	*No damage.*
543.562	

led inner rings.

In addition some failed (and unfailed) THUs (8 failed and 5 unfailed inner rings, all IB, from 13 THUs), were examined, see below in table 3.

Ryder's code		*Miles*	*Remarks*
E1752375	*IB*	*273.721*	
E1750339	*IB*	*689.347*	
CWA06549	*IB*	*385.007*	
CWA07833	*IB*	*?*	*Not failed*
E1744715	*IB*	*268.745*	*Not failed*
E1752410	*IB*	*192.639*	
E1727708	*IB*	*1.165.585*	
E1755522	*IB*	*403.200*	
Ryder 33620	*IB*	*482.615*	
Ryder 33623	*IB*	*615.339*	*Not failed*
E1755559	*IB*	*438.508*	*Not failed*
Ryder 3617	*IB*	*393.580*	*Not failed*
E1752364	*IB*	*308.528*	

Table 3. Inspected inner rings, including failed ones.

And 2 failed THUs with different seals (R-safe), see table 4, were inspected in Schweinfurt. Due to time considerations, these could only be briefly inspected.

Ryder's code		*Miles*	*Remarks*
E1732589	*IB/OB*	*91.572*	*IB failed*
33204	*IB/OB*	*109.318*	*IB failed*

Table 4. Two additional THUs, with different seals.

Later a new knuckle was also delivered, from Schweinfurt to ERC, and visually inspected.

The performed inspections showed the following features:

1.1 Raceway appearances.

The raceways, contact paths, of the unfailed bearings showed in general a good appearance, i.e. the bearings could clearly have run longer.
The three bearings delivered to ERC showed running tracks being slightly shiny, see photographs in enclosure 1. The shiny appearance is an early stage of adhesive wear or surface distress. This is a strong indication of a not ideal lubrication condition. The difference between these three bearings was that the IRs of unit no. 918279 IB (in board) and no. 918287 IB were slightly more shiny and slightly discoloured. The 918287 IB inner ring had also indentations due to over rolling of particles.

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The unfailed bearings in Schweinfurt showed a very similar surface appearance as the three examined at ERC. At 8 of the 13 bearings, in table 3, large spalls, length = approximately a quarter to a half of the circumference and full width, were present on the IR raceway. Since the spalls were very far advanced it is difficult to find the initiation point and hence the reason for failure. The spalls were in general shallow. The unspalled areas on the raceway of the rings were very shiny, i.e. advanced adhesive wear with plastic deformation of the finishing (grinding) lines and surface distress. The combined observations of the spalls and the surface appearance of the remaining raceway (i.e. the unspalled part) gave the indication that the spalling was surface initiated.

The rollers showed a (logical) corresponding appearance, i.e. for the unfailed bearings a slightly shiny surface.

For the failed bearings the damage was, logically, in a more advanced stage, i.e. stronger shiny appearance and even small spallings on the running track of the rollers.

For the appearance of the roller ends (in contact with large flange) see chapter 1.4.

1.2 Fretting corrosion.

On several surfaces fretting corrosion was observed, these were:

- inner ring bore. All investigated rings, at ERC *as well as in Schweinfurt*, fretting corrosion was found in the bore. This varied from being hardly visible to very strong in appearance. There was a clear tendency that the ring in the in-board position had stronger fretting than the ring in the out-board position. The fretting was, logically, concentrated in the loaded position. However, sometimes the fretting was present around the complete circumference, but, then mostly strongest in the loaded position. Photographs are shown in enclosure 1, figures 1-4.

- inner ring side-face, thin section. All investigated rings, at ERC *as well as in Schweinfurt*, had fretting corrosion in this position. In some of the rings in Schweinfurt the fretting was present on the whole circumference. But the general appearance was that this fretting was concentrated (and started) at the positions 90 ° and 270 °. See photograph, figure 5, in enclosure 2.

- inner ring side-face, thick section. All investigated rings, at ERC *as well as in Schweinfurt*, showed to have fretting corrosion in this position. In some of the rings the appearance had a specific mode which could be related to the poor surface finishing of the corresponding surface on the knuckle. See photographs, figures 6-9, enclosure 2.

1.3 Moisture corrosion.

Corrosion, most probably due to the presence of water, was found in the following positions:

- inner ring bore, contact surface with shaft. This "normal" red rust was found on almost all rings. See photographs, figures 10 and 11, in enclosure 3.

- inner ring bore, thin section. This corrosion was found in the position where the load had been applied, 0°, which indicates the it occurred during stand-still. See photographs, figures 12 and 13, in enclosure 3.

- on the clamping ring. Also on these rings red rust was found. See photographs, figures 14-17, in enclosure 4.

- on the shoulder of IR large flange. *This was only found on four inner rings in table 3, of which one was not failed. On one of the shoulders the corrosion was present with a width corresponding to the full width of the seal. At the other three shoulders the width corresponded to half the seal width, i.e. the outer part and an indication of that the inner seal-lip still had functioned well.*

1.4 Sliding/wear.

Sliding with resultant wear (smearing) was observed at the surface contact between the roller end and the large flange. All investigated rings, at ERC *as well as in Schweinfurt*, showed to have this. Some, not failed, showed to have small spalls, i.e. material broken out. Photographs are shown in enclosure 4, figure 18-19.
At some failed bearings this was very strong, with spalls on the roller and surfaces as well as on the flange. In two cases the flange was also blue coloured by heat.

For the sliding of the seals see next chapter, 1.5.

1.5 Seals & shoulders in contact.

As a result of the sliding of the seals on the shoulder of the large inner ring flange, shiny bands were noticed on the rings. This appeared in different severities and inspection of the seals showed corresponding wear of the seal-lips. The wear of the seal-lips was judged as slight, i.e. most of the lips are still present and no indication for not functioning could be found.
See photographs, figures 20 – 24, in enclosure 5.

1.6 Other observations.

The general appearance of the outer rings in the THUs at BRC corresponded well to what had been noticed on the inner rings, i.e. still in relatively good condition.

In general the THUs at ERC were judged as THUs which were still functioning well.

The appearance of the bolts, on the three THUs at ERC, can be seen in enclosure 6. Moisture corrosion was present as well as on the large flange of the THUs. On the part where the nuts have been positioned wear of the thread was noticed.

On the flange, around the bolts, it could be seen that the positioning of the wheels on the THU was off centre.

The inspected, unfailed, bearings in Schweinfurt, table 2, had also been inspected by Ryder. The following discrepancies in the results of the inspections were noticed:
At one ring flaking had been noticed by Ryder but could not be found.
For some rings creeping had been observed by Ryder but was also not found.

Some photographs of the in Schweinfurt briefly inspected bearings, from table 4, are shown in enclosures 7-10.

The results of the inspections performed by SKF in Schweinfurt are conforming very well with the results of the inspections performed in ERC.

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Enclosure 1.

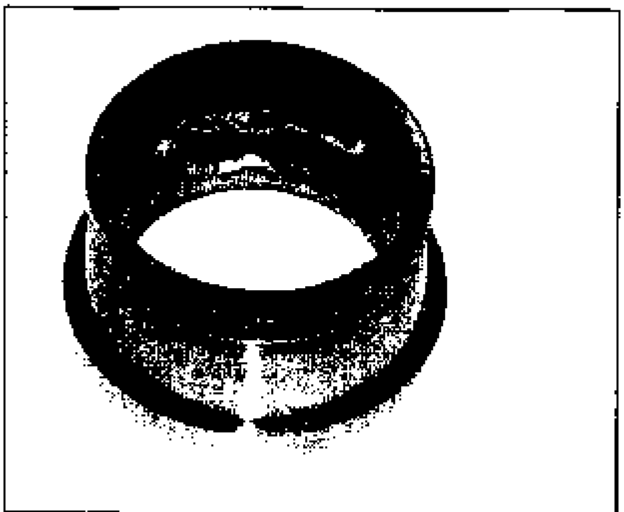

Fig. 1. 918279-B (IB) showing rather strong fretting corrosion in the position where the load had been applied. The 918279-A (OB) ring had no fretting.

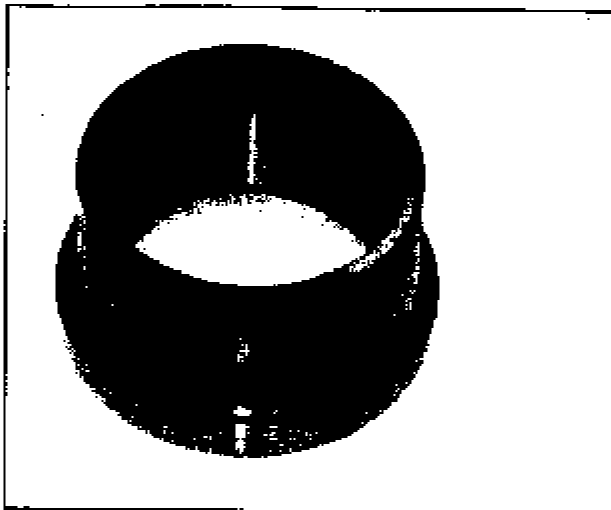

Fig. 2. 918279-B-(IB) showing no fretting in the opposite position, where no load had been applied. Here the slight discolouring of the raceway, loaded zone, is visible.

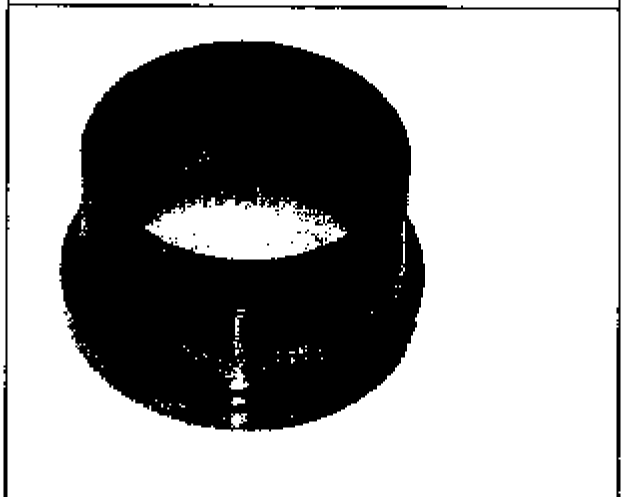

Fig. 3. 918287-IB showing rather strong fretting corrosion in the position where the load had been applied. The 918287-OB ring showed a very similar appearance.

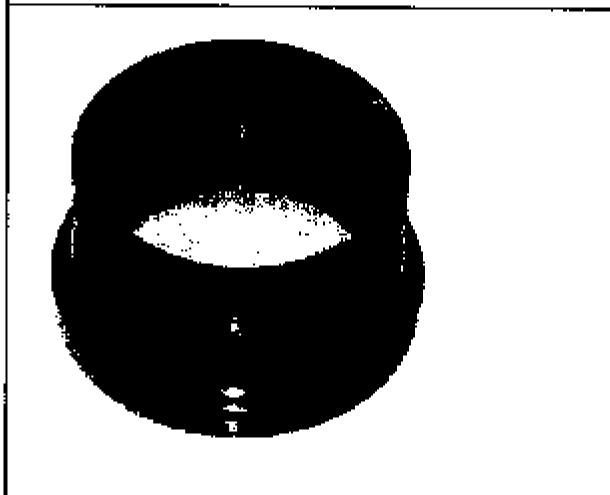

Fig. 4. 918287-IB showing slight fretting in the opposite position, where no load had been applied. Here slight discolouring of the raceway, loaded zone, is visible.

Enclosure 2.

Fig. 5. Bearing: 918287-IB. Side-face small flange. Fretting positioned at 90 ° & 270 ° from loaded zone.

Fig. 6. Bearing: 918287-IB. Side-face large flange. Normal appearance of the complete circumference.

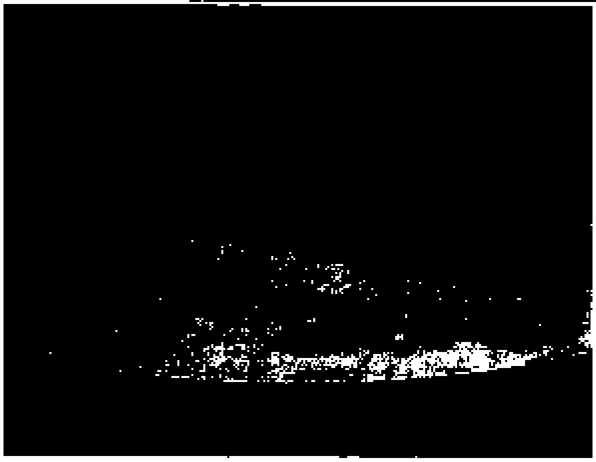

Fig. 7. Bearing: 918287-IB. Side-face large flange. Special appearance locally. Only on the IB rings.

Fig. 8. See figure 9. Red square at higher magnification. This appearance was present in two positions opposite each other, approximately 180°.

Fig. 9. Red square showing position of figure 8.

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Enclosure 3.

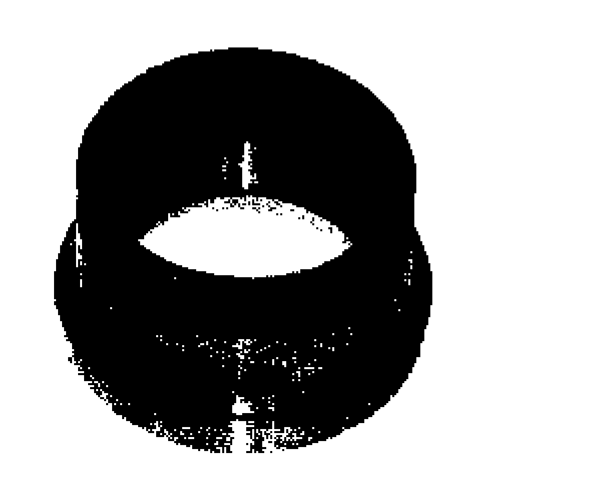

Fig. 10. Bearing: 317572-IR-OB, 90 ° from loaded zone. Showing moisture corrosion in the bore.

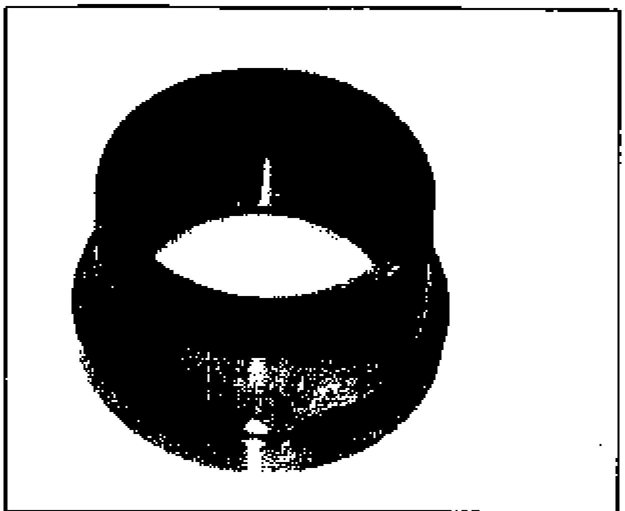

Fig. 11. Bearing: 317572-IR-OB, 270 ° from loaded zone. Showing moisture corrosion in the bore.

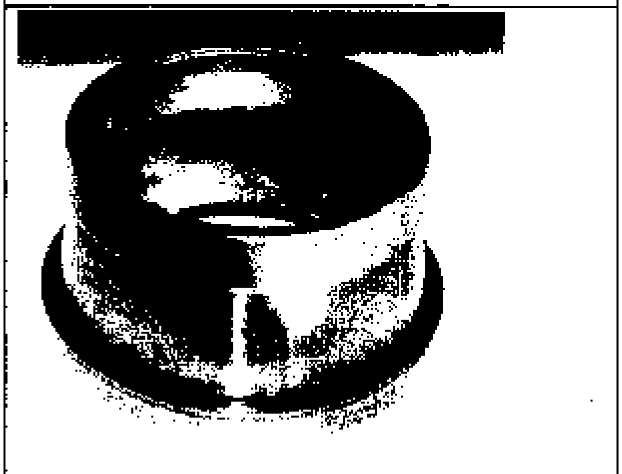

Fig. 12. Bearing: 918287-IB, bore is loaded zone. Showing the moisture corrosion in the bore at the thinnest section of the ring.

Fig. 13. Bearing: 918287-IB. Showing the moisture corrosion in the bore at the thinnest section of the ring, as shown in fig. 12

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Enclosure 4.

Fig. 14. Clamping ring from no. 918279.
Showing the presence of moisture corrosion.

Fig. 15. Clamping ring from no. 918279.
Showing the presence of moisture corrosion.

Fig. 16. Clamping ring from no. 918287.
Showing the presence of moisture corrosion.

Fig. 17. The bore of the clamping ring from no. 918287.
Showing the presence of moisture corrosion.

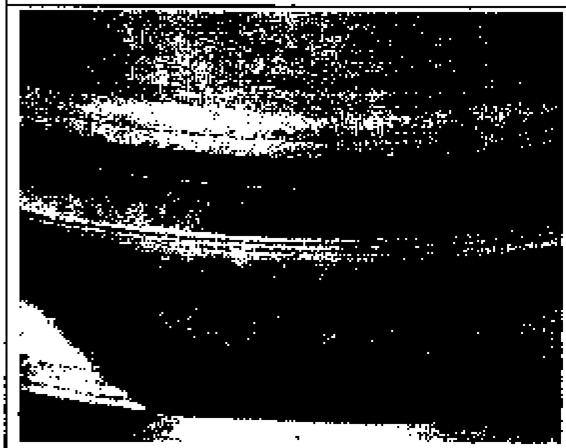

Fig. 18. Bearing: 918287-IB-flange

Fig. 19. Bearing: 918287-IB-roller end

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Enclosure 5.

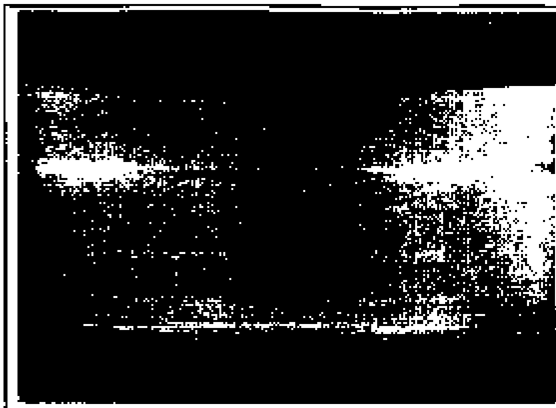

Fig. 20.Bearing: 918279-B-(IB), Large flange shoulder. Showing the wear marks where the seal-lips had been in contact.

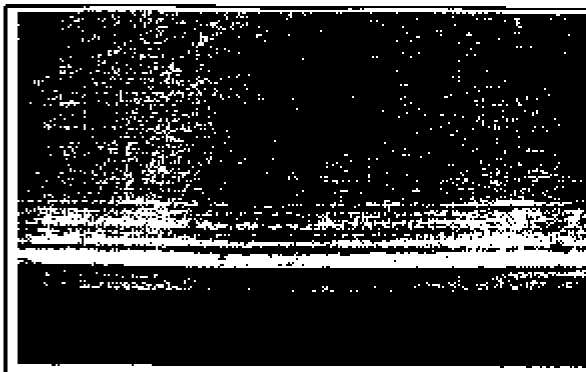

Fig. 21.Bearing: 918279-B-(IB), Large flange shoulder. Higher magnification of fig. 20. Showing the wear marks where the outer seal-lips had been in contact.

Fig. 22. The seal out of 317572-IB.
Lips still almost as new.

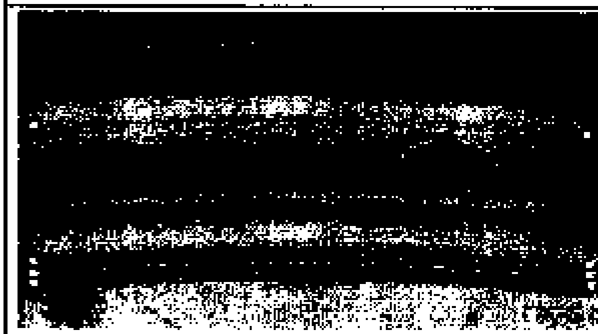

Fig. 23. The seal out of 918279-IB.
Very slightly worn outside lips. Inside lip (in position of the single white dots) hardly visible since grease is removed.

Fig. 24. The seal out of 918287-IB.
Slightly worn outside lips.
The "dirt" is dark grease. Most being wiped off on the seals in figures 22 and 23 before photographing.

◄ Lip inside. Single dot in fig. 23

◄ Lips outside. Triple dot in fig 23.

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Enclosure 6.

Fig. 29. Showing the appearance of bolts in THU no. 918279. Approximately half of the visible part of the bolts, closest to the flange, is showing wear of the threads.

Fig. 30. Showing the appearance THU no. 317572. The bolts being somewhat more corroded than in the other two THUs. The corroded area on the flange around the bolts are showing that the wheel has been positioned off center. This was the case for all three THUs.

Fig. 31. Showing the appearance THU no. 918287, being rather similar as no. 918279.

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Enclosure 7.

Claim no.: E1752589. 91.572 miles. Failed inboard (IB) inner ring. With an O-ring on the spindle. The seal had a mounting defect.
The OB ring in this THU had only slight fretting in the bore at the loaded area, (0°), and slight wear on the flange/roller contact surfaces.


Fig. 32. IB ring. Fretting in the bore (loaded)

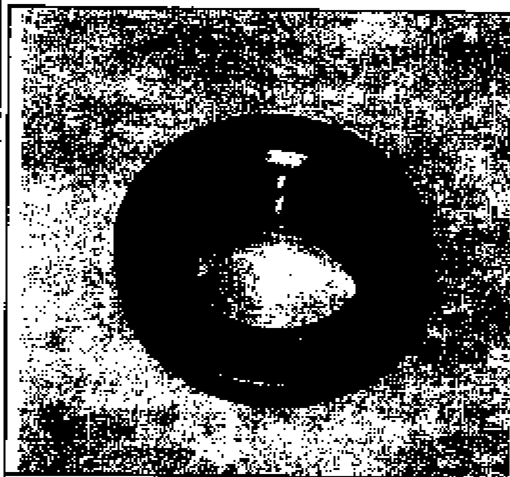
Fig. 33. IB ring. Bore (unloaded). No fretting. No corrosion.


Fig. 34. IB ring. The spalling (loaded).


Fig. 35. IB ring. Unloaded part.

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Enclosure 8.

Claim no. 33204. 109.318 miles. Failed outboard (IB) inner ring.
The OB ring in this HUB had only slight fretting in the bore at the loaded area, (0°), and slight wear on the flange/roller contact surfaces.

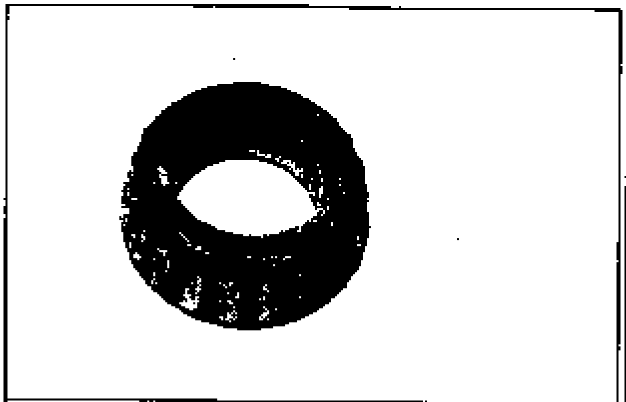

Fig. 36. IB ring. Bore loaded part, 0°.
Fretting (and possibly corrosion) present.

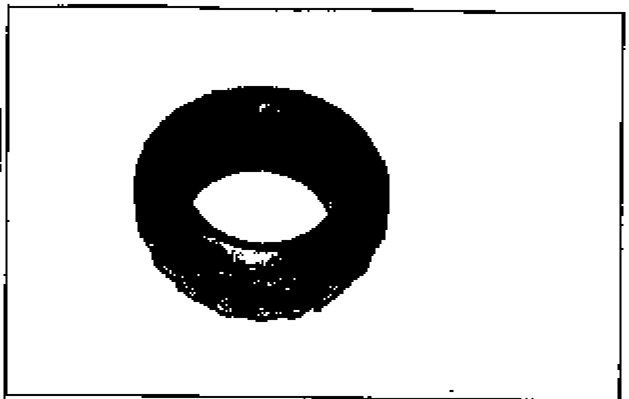

Fig. 37. IB ring. Bore loaded part, 0°.
Fretting (and possibly corrosion) present.

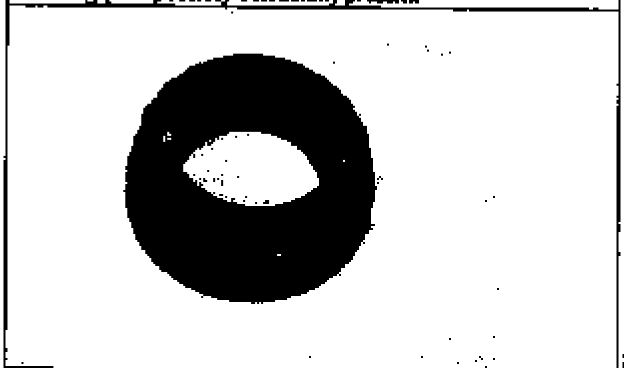

Fig. 38. IB ring. Bore at 90°. Some fretting present.

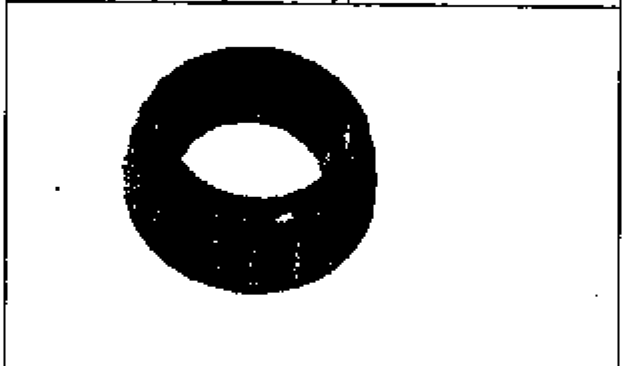

Fig. 39. IB ring. Bore unloaded part, 180°.
Fretting and/or corrosion present.

Fig. 40. IB ring. Bore at 270°. Clean area.

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Enclosure 9.

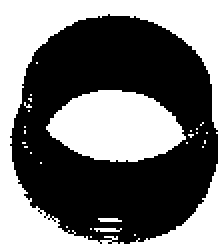

Fig. 41. IB ring. Bore loaded part, 0°.
Fretting (and possibly corrosion) present.

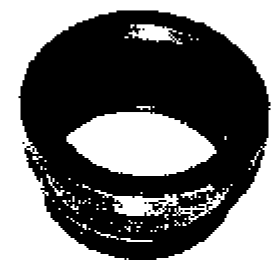

Fig. 42. IB ring. Bore loaded part, 0°.
Fretting (and possibly corrosion) present.

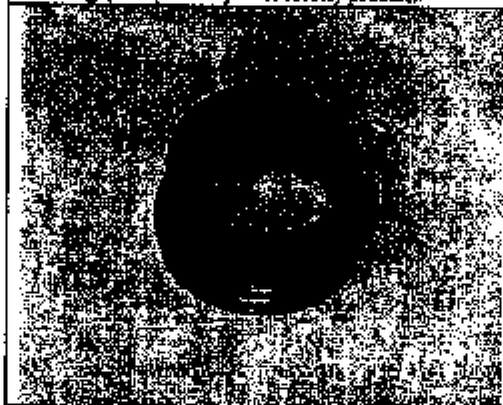

Fig. 43. IB ring. Bore unloaded part, 180°.
Fretting and/or corrosion present.

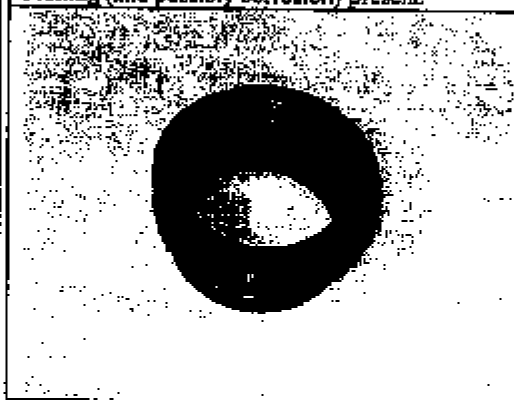

Fig. 44. IB ring. Bore unloaded part, 180°.
Fretting and/or corrosion present.

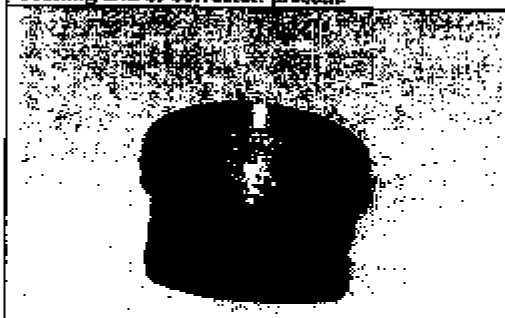

Fig. 45. IB ring. The spall in loaded area (0°).

Fig. 46. IB ring. Unloaded area (180°).

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Enclosure 10.

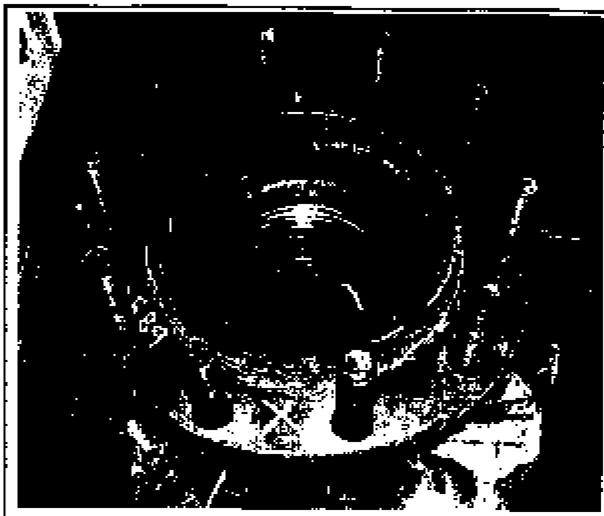

Fig. 47. Claim no.: E1752589. 91.572 miles.

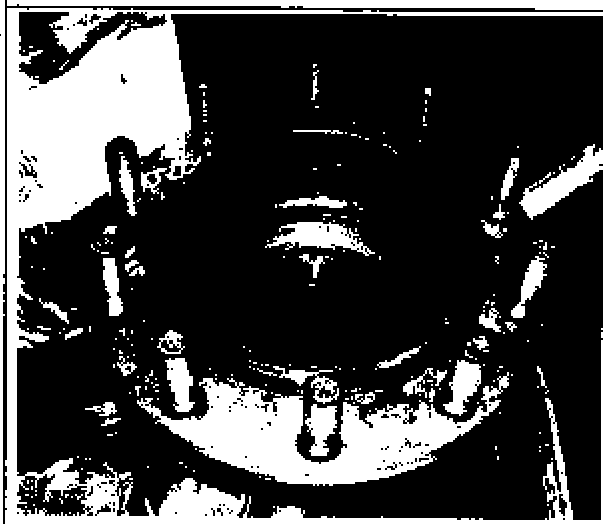

Fig. 48. Claim no. 33204. 109.318 miles.

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ArvinMeritor THUs from the Field: Final Report

Aidan Kerrigan

Materials Theory & Testing

ArvinMeritor THUs from the Field: Final Report

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Key Words THU, visual inspection, grease analysis, surface analysis, SEM, x-ray, fretting, corrosion, fatigue, water

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ArvinMeritor THUs from the Field: Final Report

Abstract This report summarises the various investigations which have been performed to assess the degree and nature of the damage on three THUs returned from the field after approximately 500,000 miles in service.

Main conclusions and recommendations

Investigation of the material response to rolling contact fatigue showed only a limited accumulation of fatigue damage, using the line broadening parameter (b/B ratio), at the depth of maximum Hertzian stress for the inner and outer rings investigated. Based on this, it is unlikely that classical sub-surface intiated fatigue will be the 'life limiting' failure mode in these THUs.

The material response results also indicate that the material and heat treatment combinations for these major components were suitable for the bearing loads experienced in service, from the point of view of classical, sub-surface initiated failure.

In unit 918287, the inboard inner ring and inboard outer ring showed some material response at the surface or near surface in that a compressive stress was generated in this region. Despite this change, the line broadening parameter (b/B ratio) remained at a relatively high level, indicating only a limited accumulation of fatigue damage at the surface.

Despite the above statement, the visual and SEM investigations showed a number of types of surface damage which had been accumulated during running in service. The raceways, in general, showed evidence of surface distress, although this had not totally removed the finish machining marks. Denting, due to overrolling of particles, was also observed in the raceways. This was present as generally distributed denting on the inboard raceways due to overrolling of deformable particles and also as more localised denting and more advanced surface distress in the form of bands at the edges of the contact, mainly on the outboard raceways but also visible on some inboard raceways. It is noted that one inboard outer ring raceway had suffered localised microspalling on one band of advanced surface distress.

The surface damage indicates a lubrication regime which is not optimum, either in terms of film thickness or in terms of cleanliness with respect to contaminant particles.

The grease from all three units was found to contain water, in a proportion of ± 1% to 1.5%. Although the effect is difficult to quantify, in terms of lubrication properties in the application conditions, it is strongly suspected that the water contamination of the grease contributed to the surface distress damage by adversely affecting the lubrication film.

From the observations of the visual inspection and SEM, combined with the x-ray results of material response, it is most likely that surface initiated fatigue will be the 'life limiting' failure mode in the three THUs investigated.

Surface fatigue is progressive, first noted as surface distress which increases in severity until micro-spalling of the surface occurs. Micro-spalling can occur locally (e.g. related to bands of advanced surface distress) or can occur generally on a raceway surface and, again, this is a progressive failure mode which can lead to larger scale spalling.

It is noted that the surface damage on the three THUs from the field was on a micro-scale, in terms of denting and surface distress, with only one raceway showing evidence of localised microspalling.

The bores of the inner rings, particularly the inboard inner rings, showed evidence of corrosion. In the position of the highest load, this would be classed as fretting corrosion, due to the darkened appearance of the surface and the removal of the finishing marks. An investigation of one inner ring from the field showed that the corrosion products in the bore at different positions had similar characteristics and that they had been formed in a damp environment i.e. in the presence of water.

Despite the damage observed in the three THUs, they were still not classified as having failed. The level of damage seen in these three THUs was certainly not advanced and does not indicate the likely specific 'life limiting' failure mechanism in more detail, other than being surface initiated.

It is recommended to further investigate the condition of the grease in units from the field. The grease sample should be taken at the time of dismounting the THU in order to eliminate doubts about the pick-up of moisture between dismounting and investigation. Note that the grease should ideally come from the raceway position to determine the extent of thickener degradation and base oil oxidation in grease that has been overrolled. Included in the grease analysis could be particle analysis, in order to indicate, if possible, the source(s) of indents on the THU raceways.

It is recommended to determine whether the small circular features are a common occurrence in THUs. If so, their nature and origin should be determined as a means of indicating how their formation can be avoided.

The results of these ERC investigations should be combined with those of SKF Schweinfurt and finite element modelling to determine the likelihood of water ingress into the THU and the possibility for migration of a damp environment.

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1 Background

Three run THUs, returned from the field, and one new unrun THU were supplied to ERC for investigation. The THU identification number, corresponding ERC identification number and number of miles covered by the THUs are shown in table 1.

THU	ERC no.	Mileage
918279	02MR0020	569,184
317572	02MR0021	560,228
918287	02MR0022	591,711
New unit	02MR0019	zero

Table 1. Investigated THUs

It should be noted that for unit 918279, the box was marked 596,184 miles while the tag on the unit was marked 569,184 miles. It was decided to use the mileage marked on the tag.

The inboard inner ring (IR) of unit 317572 was not supplied. All components of the other THUs were supplied.

In addition to the investigations on these three THUs from the field, further examples of returned THUs were examined in SKF Schweinfurt and the observations are included in this report.

2 Summary of Investigations

2.1 Visual Inspection [Ref. 1]

The three THUs delivered to ERC had not failed and could still have been used in the field. These THUs were in the ideal condition for a determination of the applied running conditions. These showed to have been tough for the bearings in term of the lubrication conditions, most likely caused by water ingress.

Additional unfailed THUs were visually inspected at SKF Schweinfurt and these showed a very similar appearance as the three THUs supplied to ERC.

Failed THUs were also visually inspected at SKF Schweinfurt and these showed the logical result of what would happen to the unfailed bearings if they had been used longer.

Some of the conclusions are only indicative as they were based purely on the visual inspection of the THUs. Bearing this in mind the following route cause for failure is suggested as the most likely:

1. The application conditions for the THUs were not ideal.

1.a. Loose fit on the shaft, resulting in fretting corrosion in the bore of the inner rings.

1.b. High bending forces on the knuckle and/or shaft, resulting in fretting corrosion on both side-faces of the inner rings.

1.c. Poor surface finishing of the knuckle surface in contact with the inner ring (in-board) had an accelerating effect on the formation of fretting corrosion.

The recommended investigations are ongoing and are required for the confirmation of the following.

2. Water entered in to the THU in the bore/shaft position.

2.a. Resulting in found moisture corrosion.

2.b. Water entered also in to the grease, resulting in poor lubrication conditions, i.e. thin film.

3. The surface initiated spalling, as observed in eight THUs in Schweinfurt, was caused by poor lubrication resulting in adhesive wear, smearing and surface distress.

4. Modelling of the loading conditions could explain if these might have contributed to a (temporary) negative effect, e.g. during braking, on the lubrication conditions and therefore have had an accelerating effect on the failure process.

2.2 Bore Corrosion Product Analysis [Ref. 2]

An individual inner ring was supplied by SKF Schweinfurt for an analysis of the corrosion products in the bore. In the bore, at the highest loaded position (nominated as 0°), there was a darkened red area, which would normally be classed as fretting corrosion. However, there was also a light red area at the 180° position, which was regarded as unusual. In general, the chamfer was not discoloured but there was a free-standing red area on the chamfer i.e. in a non-contacting location. These four areas were subjected to analysis at the University of Surrey, UK, using x-ray photoelectron spectroscopy (XPS). This technique is used to determine the chemical species by measurement of the chemical bonding energies.

According to the results and interpretation from the University of Surrey, the products in the bore of the THU inner ring at the 0° and 180° positions had similar characteristics and were an Fe(III) compound, most probably FeOOH, which is formed in a humid environment i.e. in the presence of water.

It should be noted that at the 0° position, the finish machining marks were not apparent but that at 180°, the finish machining marks were still visible.

On the (non-contacting) chamfer, the non-discoloured surface had an Fe_2O_3 type of deposit. This was stated to have been formed in a dry environment, at a 'slightly elevated' temperature, probably during heat treatment.

The free-standing red area on the chamfer was analysed and also found to be an Fe_2O_3 type of deposit, again formed in a dry environment.

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The results at the 0° and 180° positions in the bore, as compared to the results from the chamfer, indicate that the technique can differentiate between different oxide species.

2.2 Grease Analysis [Ref. 3]

The grease from the three THUs from the field was not SKF GWZ but was likely to be grease GEJ i.e. Shell Calithia EP2.

In general, the grease from the three THUs returned from the field was in good condition in that there was no evidence of thickener degradation or base oil oxidation. However, it should be noted that the grease samples were taken from the outer ring at a position between the two raceways. The samples, therefore, may not reflect the condition of grease overrolled in the contact zone.

The samples from the three THUs returned from the field gave a clear indication that the grease contained water. The estimated water content in the samples was:

- THU no. 317572: ± 1% water
- THU no. 918287: ± 1% water
- THU no. 918279: ± 1.5% water

2.3 Scanning Electron Microscopy [Ref. 4]

The three THUs from the field have suffered damage during the ± 500,000 miles in service but were not classified as having failed. There were many similarities in the character of the damage in the three units, although it is noted that the components of units 918279 and 918287 tended to show clearer evidence of the damage than those of unit 317572.

Bearing in mind that the inboard inner ring of unit 317572 was not supplied, the following general statements can be made on the nature of the observed damage.

All raceways showed evidence of surface distress in that the finish machining marks were removed to some extent. The surface distress, in general, was not very advanced since finishing marks were still visible and there was no microspalling of the surface. One exception was the outer ring of unit 918287, which will be covered later.

Small (< 5 μm diameter) circular features were observed on all raceways but the mechanism for their formation is not clear. It is noted that on the inboard inner rings, the features were linked to localised areas of more advanced surface distress, although microspalling was not observed in these areas.

The inboard raceways had smooth dents, formed by the overrolling of deformable particles. This type of damage was not seen on the outboard raceways.

The outboard raceways, particularly the inner rings, had bands of dense fine denting and more advanced surface distress. These bands were concentrated towards the edge of the contact, nearest the thin section of the outboard inner rings or the equivalent location on the outboard outer rings and rollers. Similar bands were seen on some inboard raceways but the degree of damage was less pronounced than on the outboard raceways.

There was contact between the roller end-face and the flange, particularly for the inboard inner rings. This resulted in removal of the finishing marks, smearing and even material loss from the flange.

The flange shoulders showed evidence of contact with the seal lips, which had resulted in mild sliding damage at the position of the inside seal lip.

On the position of the external seal lip, pit-like features were observed. These pits contained dust and apparent material from the seal. There may also have been products from aqueous corrosion in some pits. It is noted that some surface corrosion was apparent outside the seal contact on the inboard inner ring of unit 918287.

The inboard outer ring raceway of unit 918287 had localised bands of advanced surface distress and associated microspalling. No other components of the units showed any evidence of microspalling.

In summary, all components examined showed evidence of surface damage on the raceways, either in the form general surface distress or localised bands of surface distress associated with fine indents. The inboard raceways had been dented by the overrolling of deformable particles and all raceways had small, micron-scale circular features.

Surface distress, whether general or localised, indicates that the lubrication film thickness is insufficient to separate the rolling contact surfaces. Surface distress is a fatigue phenomena and, as such, is progressive and, over time, can lead to microspalling, as was seen very locally on the inboard outer ring raceway of unit 918287.

The contact between the roller end-face and the IR flange also indicates a poor lubrication film in this region.

It is recommended to investigate whether the small circular features are common to THUs and, if so, to determine their origin in order to avoid their formation.

2.5 X-Ray Analysis [Ref. 5]

The investigated inboard inner ring of unit 918279 did not show evidence of the accumulation of rolling contact fatigue damage to any significant extent at the centre of the raceway.

The inboard inner ring of unit 918287 showed evidence of a change in the residual stress profile in the raceway towards the edge of the overrolled track at the thinner end of the inner ring section due to running in the application. This change was in the form of the development of a compressive stress in the near surface region, which represents a material response to rolling contact fatigue. However, the line broadening parameter (b/B ratio) had a relatively high value, indicating only a limited accumulation of fatigue damage.

At the other measured positions of the inboard inner ring and all positions measured on the outboard inner ring of unit 918287, there was no evidence of significant material response to rolling contact fatigue.

The inboard raceway of the outer ring of unit 918287 gave an indication of surface fatigue, although the response was not as clear as that shown by the inboard inner ring (at the thinner end).

The outboard raceway of the outer ring of unit 918287 did not give an indication of a significant material response to rolling contact fatigue.

In summary, none of the THU components measured showed any evidence of the accumulation of sub-surface fatigue from the Hertzian stress induced by a rolling contact in the application.

Based on the residual stress profiles, there was evidence of a material response at the surface or near surface of the inboard inner ring raceway and the inboard outer ring raceway of unit 918287. In the absence of a sub-surface fatigue response, this would suggest that surface initiated fatigue would be the most likely failure mode. However, it is noted that the line broadening parameter (b/B ratio) remained at a relatively high value, indicating only a limited accumulation of fatigue damage at the surface or near surface region.

3 Discussion

The residual stress profiles and line broadening (b/B) profiles measured on the THU components show that there was only a limited material response to rolling contact fatigue (RCF) in the sub-surface region i.e. at the depth of maximum Hertzian stress. This observation was valid for the inboard inner ring of unit 918279, the inboard and outboard inner rings of unit 918287 and the inboard and outboard raceways of the outer ring of unit 918287. This means that the through hardened grade 3 inner rings and surface induction hardened grade 55 outer rings did not show any clear indication of the development of sub-surface fatigue after ±500,000 miles in service. This, in turn, would indicate that the material and heat treatment combinations for these major components were suitable for the bearing loads experienced in service, from the point of view of classical, sub-surface initiated failure.

Note:
Grade 3 is an SKF steel designation and is equivalent to ASTM A295-98 52100. Grade 55 is also an SKF steel designation and is equivalent to ISO 683-17:1999 steel type B40.

The residual stress profiles of the inboard inner ring (at the thin section) and the inboard outer ring raceway (at the three measured positions) of unit 918287 showed a material response at the surface and near surface region. This was apparent due to the development of a compressive stress of a higher magnitude than existed in the equivalent component from a new unrun THU. Despite this, the line broadening parameter (b/B) had relatively high values (≥ 0.90), indicating only a limited accumulation of fatigue at the surface and near surface region. (The b/B ratio has a maximum value of 1.0 and decreases with increasing accumulation of fatigue).

Surface fatigue can be due to one or a number of contributing factors such as particle contaminated lubrication or metal-to-metal contact, which in turn indicates a lubrication regime which is not optimum.

The SEM investigation clearly showed smooth indentations on the raceways of components on the inboard side of the THUs. Smooth indents are formed due to the overrolling of deformable particles and these particles are typically metallic. It should be noted that metallic particles are deformable in a Hertzian contact even if the particles are hard. The smooth indents seen on the inboard raceways were not seen on the outboard raceways.

The outboard raceways, however, did have bands of dense fine denting and associated surface distress. These bands were concentrated towards the edge of the contact, nearest the thin section of the outboard inner ring (or the equivalent position on the rollers and the outer ring although less clear on these components). The surface distress associated with the bands was more advanced than generally seen on either the inboard or outboard raceways. Bands of dents, at the edge of the contact, were also seen on the inboard raceways but to a much lesser extent than on the outboard raceways.

Both inboard and outboard raceways, therefore, show evidence of indentation by overrolling of particles. In the outboard raceways, the indenting was on a small scale and specifically at the edge of the contact, and associated with more advanced surface distress. For the inboard raceways, the indenting was in the form of general overrolling of deformable particles with some evidence of similar bands of dents at the edge of the contact.

The raceway surfaces, in general, showed evidence of moderate surface distress in that the finishing marks were removed to some extent, although the deeper finishing marks were still present. The existence of surface distress indicates some metal-to-metal contact between the ring raceways and those of the rollers. This can be caused by localised lubrication film breakdown, such as in the presence of indentations, or be the result of a lubrication film which, in general, is not sufficient to separate the surfaces.

Surface distress is a fatigue phenomena and, as such, is progressive and, over time, can lead to microspalling, as was seen very locally on the inboard outer ring raceway of unit 918287.

In unit 918279, the inboard inner ring had slightly more advanced surface distress as compared to the outboard inner ring although this difference between inboard and outboard inner ring raceways was less apparent in the unit 918287. (The inboard inner ring of unit 317572 was not supplied).

The overrolled tracks of the inboard inner rings of units 918279 and 918287 showed that the loading tended to be towards the thicker flanged section, such that the roller end-

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face contacted the flange. This contact resulted in the removal of the finish machining marks on the flange by surface distress, smearing of the flange surface and even material loss. This would also suggest rather poor or very thin film conditions at the roller end-face contact with the flange.

Because of the evidence of general surface distress on the raceways and at the roller end-face contact with the flange, the condition of the grease was investigated. The FT-IR analysis showed that the GEU (Shell Calithia EP 2) grease in the three units from the field all contained a proportion of water, of the order of 1%. Note that the grease samples were taken from a position between the outer ring raceways i.e. inside the THU.

It is generally accepted that water contamination of grease is detrimental for bearing performance, either due to adversely affecting the lubrication properties of the grease or even causing standstill corrosion. In the case of the three THUs returned from the field, there was no evidence of standstill corrosion on the raceways. However, the water in the grease may have contributed to the development of the general surface distress observed on the raceways and the surface distress and smearing seen at the contact between the roller end-face.

It is acknowledged that the FT-IR analysis also indicated that, despite the presence of water, there was no evidence of grease thickener degradation or base oil oxidation. However, it is noted that the samples were taken from a position between the two raceways of the outer ring and, as such, may not reflect the condition of the grease overrolled in the contact.

The results of the XPS analysis indicated that the darkened red product at the highest loaded position of an inner ring bore (0°) and the light red product in the bore (located at approximately 180°) were both FeOOH, which is formed in a damp environment.

At the 0° position, the finishing marks were not visible and this damage, in combination with the darkened red area, would be classified as fretting corrosion. At the 180° position, the finishing marks were still visible, despite the light red deposit at that location.

It is noted that the THU has a loose fit on the inner ring. According to information received [Ref.6], the maximum specified spindle diameter is 64.976 mm while the smallest specified inner ring bore is 64.985 mm, giving a difference of minimum 9 μm. This would suggest that a space exists for a humid atmosphere to form between the inner ring and the spindle.

The investigations performed cannot draw definitive conclusions regarding a link between the damp environment between the spindle and the inner ring bore and the presence of water in the grease. It is noted that finite element modelling of the dynamics of the THU may indicate possibilities for a physical link between the grease inside the unit and the environment between the spindle and the inner ring bore.

(It is noted that an investigation in SKF Schweinfurt [Ref.7] has found evidence of corrosion pits in the outer ring of a unit returned from the field and concludes that water entered the unit from the outboard side. The type of damage seen in this unit was not observed in the three units supplied to ERC for investigation).

In the three units supplied to ERC, there was evidence of corrosion on other surfaces of the unit in that the clamping ring showed clear evidence of red rust (moisture corrosion) on a non-contacting surface. In the SEM investigation, small pit-like features were seen on the flange shoulders which may have contained the products from aqueous corrosion. It is noted that some pits also contained dust particles and may also have contained material from the seal.

The small circular features observed on the raceways in the SEM have a similar appearance to electrical erosion damage but do not exhibit the 'melted' microstructures typically associated with this form of damage. Using the SEM EDAX facility, it was possible to determine that these features were not carbides, which in grade 3 have a measurably higher chromium content than the matrix. Plus the fact that the size of the small circular features tended to be larger than the carbides in grade 3, which are typically less than 1 μm in diameter. The EDAX investigation also showed that the small circular features were not related to inclusions.

The mechanism of formation of the micron-scale circular features on the raceways is unclear, as is the potential effect on bearing performance. As with dents, it can be speculated that the small circular features contribute to a localised breakdown of the lubrication film and, hence, promote metal-to-metal contact and surface fatigue.

4 Conclusions and Recommendations

Investigation of the material response to rolling contact fatigue showed only a limited accumulation of fatigue damage, using the line broadening parameter (b/B ratio), at the depth of maximum Hertzian stress for the inner and outer rings investigated. Based on this, it is unlikely that classical sub-surface initiated fatigue will be the 'life limiting' failure mode in these THUs.

The material response results also indicate that the material and heat treatment combinations for these major components were suitable for the bearing loads experienced in service, from the point of view of classical, sub-surface initiated failure.

In unit 918287, the inboard inner ring and inboard outer ring showed some material response at the surface or near surface in that a compressive stress was generated in this region. Despite this change, the line broadening parameter (b/B ratio) remained at a relatively high level, indicating only a limited accumulation of fatigue damage at the surface.

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Despite the above statement, the visual and SEM investigations showed a number of types of surface damage which had been accumulated during running in service. The raceways, in general, showed evidence of surface distress, although this had not totally removed the finish machining marks. Denting, due to overrolling of particles, was also observed in the raceways. This was present as generally distributed denting on the inboard raceways due to overrolling of deformable particles and also as more localised denting and more advanced surface distress in the form of bands at the edges of the contact, mainly on the outboard raceways but also visible on some inboard raceways. It is noted that one inboard outer ring raceway had suffered localised microspalling on one band of advanced surface distress.

The surface damage indicates a lubrication regime which is not optimum, either in terms of film thickness or in terms of cleanliness with respect to contaminant particles.

The grease from all three units was found to contain water, in a proportion of ± 1% to 1.5%. Although the effect is difficult to quantify, in terms of lubrication properties in the application conditions, it is strongly suspected that the water contamination of the grease contributed to the surface distress damage by adversely affecting the lubrication film.

From the observations of the visual inspection and SEM, combined with the x-ray results of material response, it is most likely that surface initiated fatigue will be the 'life limiting' failure mode in the three THUs investigated.

Surface fatigue is progressive, first noted as surface distress which increases in severity until micro-spalling of the surface occurs. Micro-spalling can occur locally (e.g. related to bands of advanced surface distress) or can occur generally on a raceway surface and, again, this is a progressive failure mode which can lead to larger scale spalling.

It is noted that the surface damage on the three THUs from the field was on a micro-scale, in terms of denting and surface distress, with only one raceway showing evidence of localised microspalling.

The bores of the inner rings, particularly the inboard inner rings, showed evidence of corrosion. In the position of the highest load, this would be classed as fretting corrosion, due to the darkened appearance of the surface and the removal of the finishing marks. An investigation of one inner ring from the field showed that the corrosion products in the bore at different positions had similar characteristics and that they had been formed in a damp environment i.e. in the presence of water.

Despite the damage observed in the three THUs, they were still not classified as having failed. The level of damage seen in these three THUs was certainly not advanced and does not indicate the likely specific 'life limiting' failure mechanism in more detail, other than being surface initiated.

It is recommended to further investigate the condition of the grease in units from the field. The grease sample should be taken at the time of dismounting the THU in order to eliminate doubts about the pick-up of moisture between dismounting and investigation. Note that the grease should ideally come from the raceway position to determine the extent of thickener degradation and base oil oxidation in grease that has been overrolled. Included in the grease analysis could be particle analysis, in order to indicate, if possible, the source(s) of indents on the THU raceways.

It is recommended to determine whether the small circular features are a common occurrence in THUs. If so, their nature and origin should be determined as a means of indicating how their formation can be avoided.

The results of these ERC investigations should be combined with those of SKF Schweinfurt and finite element modelling to determine the likelihood of water ingress into the THU and the possibility for migration of a damp environment.

5 References

Ref.1 G. de Wit, ERC report NL02T903e, 'Meritor THUs from the Field: Visual Inspection'

Ref.2 A. Kerrigan, ERC report supplement NL02T903e, 'ArvinMeritor THUs from the Field: Bore Corrosion Product Analysis'

Ref.3 A. Kerrigan, ERC report NL02M902e, 'ArvinMeritor THUs from the Field: Grease Analysis'

Ref.4 A. Kerrigan, ERC report NL02M903e, 'ArvinMeritor THUs from the Field: Scanning Electron Microscopy'

Ref.5 A. Kerrigan, ERC report NL02M904e, 'ArvinMeritor THUs from the Field: X-Ray Analysis'

Ref.6 A. Möller, internal SKF memo dated 2002-07-18

Ref.7 SKF Schweinfurt report Nr. 186/02, issued 2002-07-11.

SKF 001409

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Discussion

Main Topic

Robert J Bondy/DET/SKF
08/06 07:47 PM

Subject: ARM Key Supplier Meeting 12 Aug02

Category: Information

ARM Meetingpp46-e.pp ARM Meetingpp31-45.pp ARM Meetingpp16-30.pp ARM Meetingpp1-15.pp

Car Corners

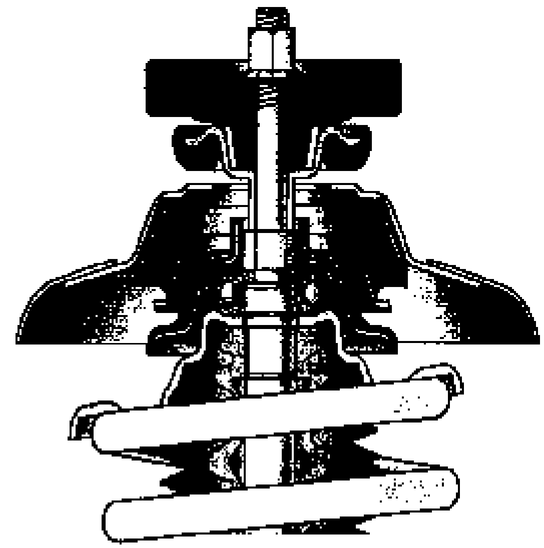
- Toyota Platform
- Hub-3 with integrated caliper mounting Bosses
- Estimate volume 500,000 /yr est
- SOP Pending results of proposals.

SKF 001411

Top Mounts

U-Van – B-Van

- Proposals have been made
- Waiting feed back from ARM
- Volume 1.4 million pcs/yr

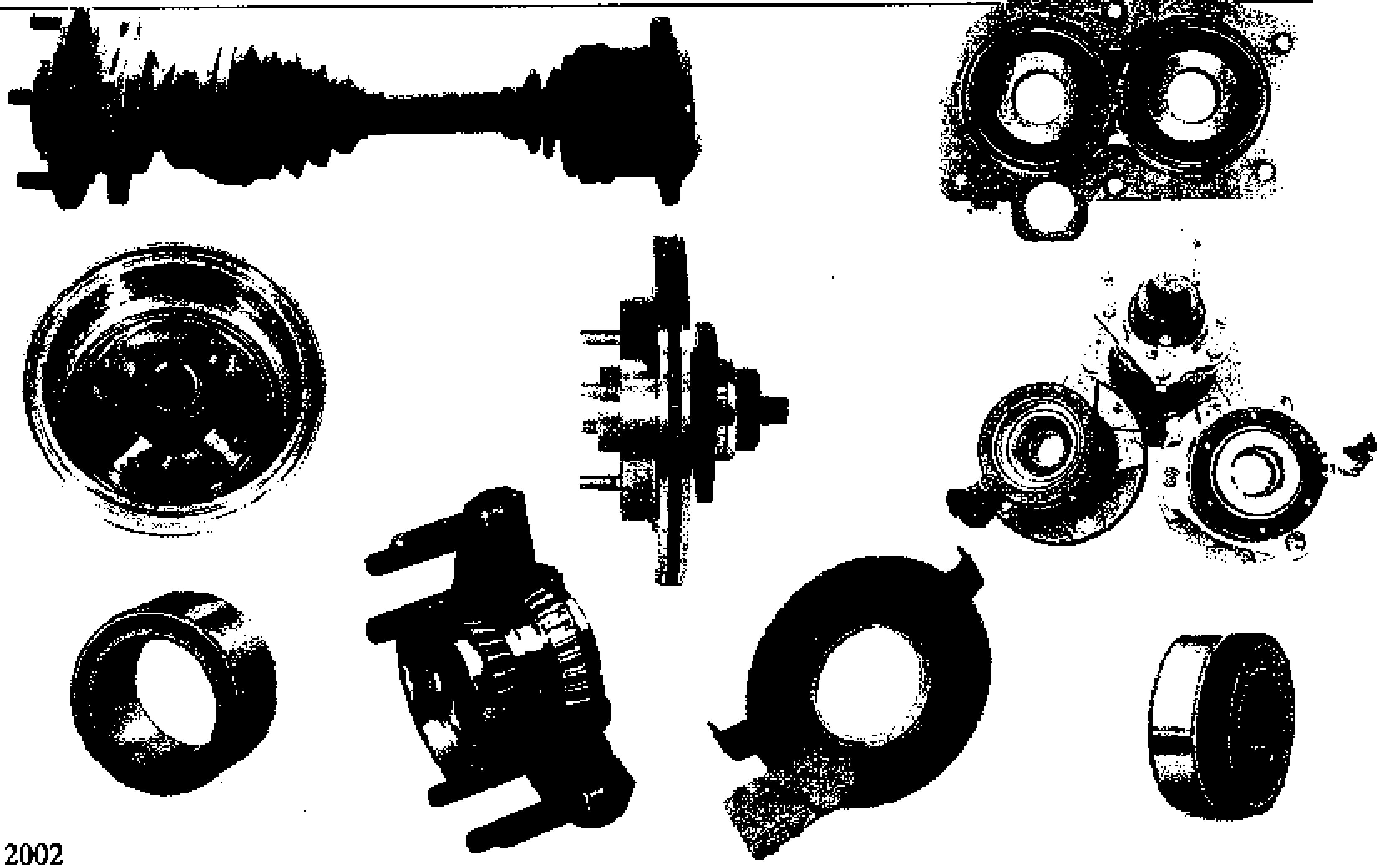


SKF 001412

Tapered Pinion Unit

SKF 001413

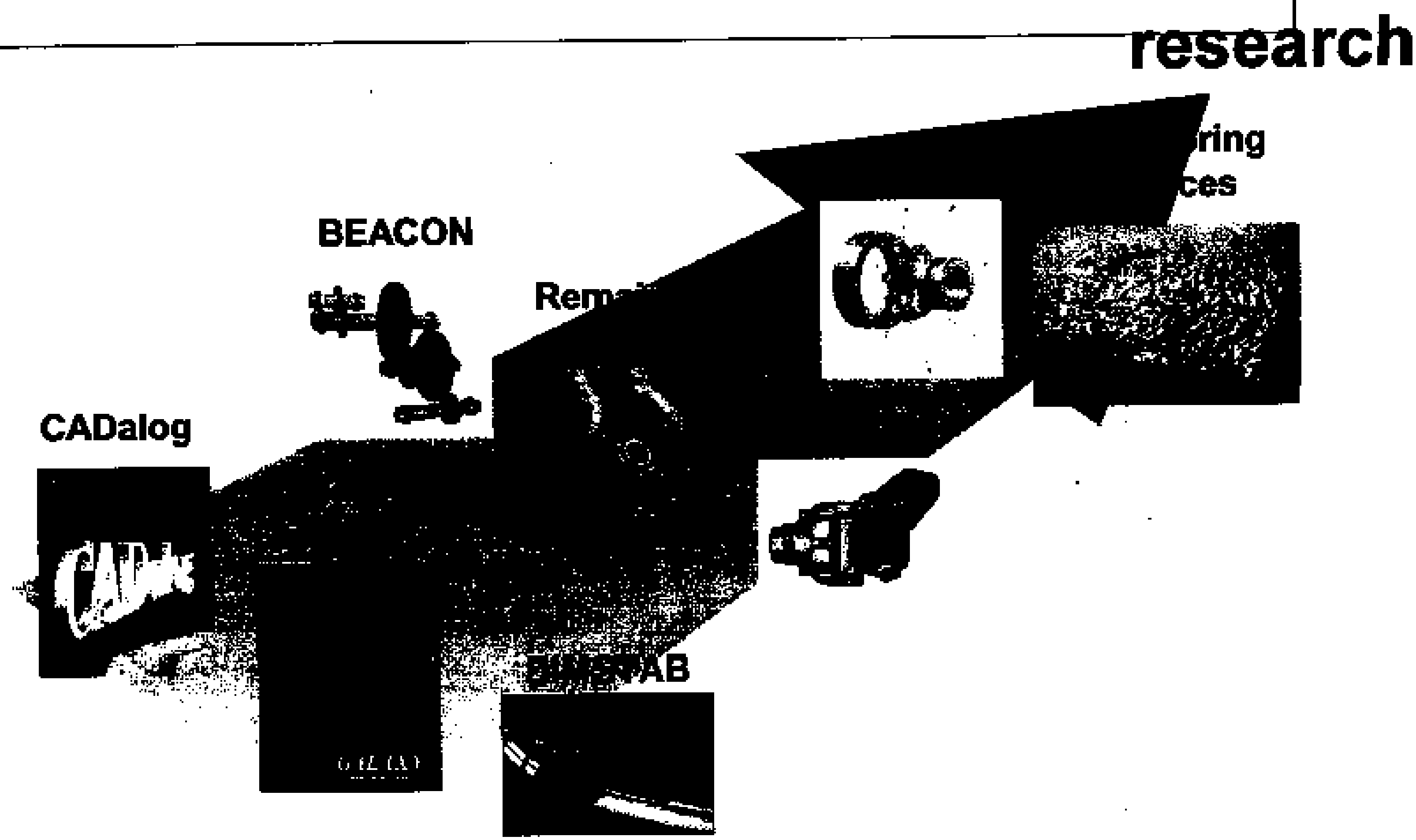
Automotive and Seals Divisions
Product Innovation



12 Aug 2002

SKF

Modeling & Simulation

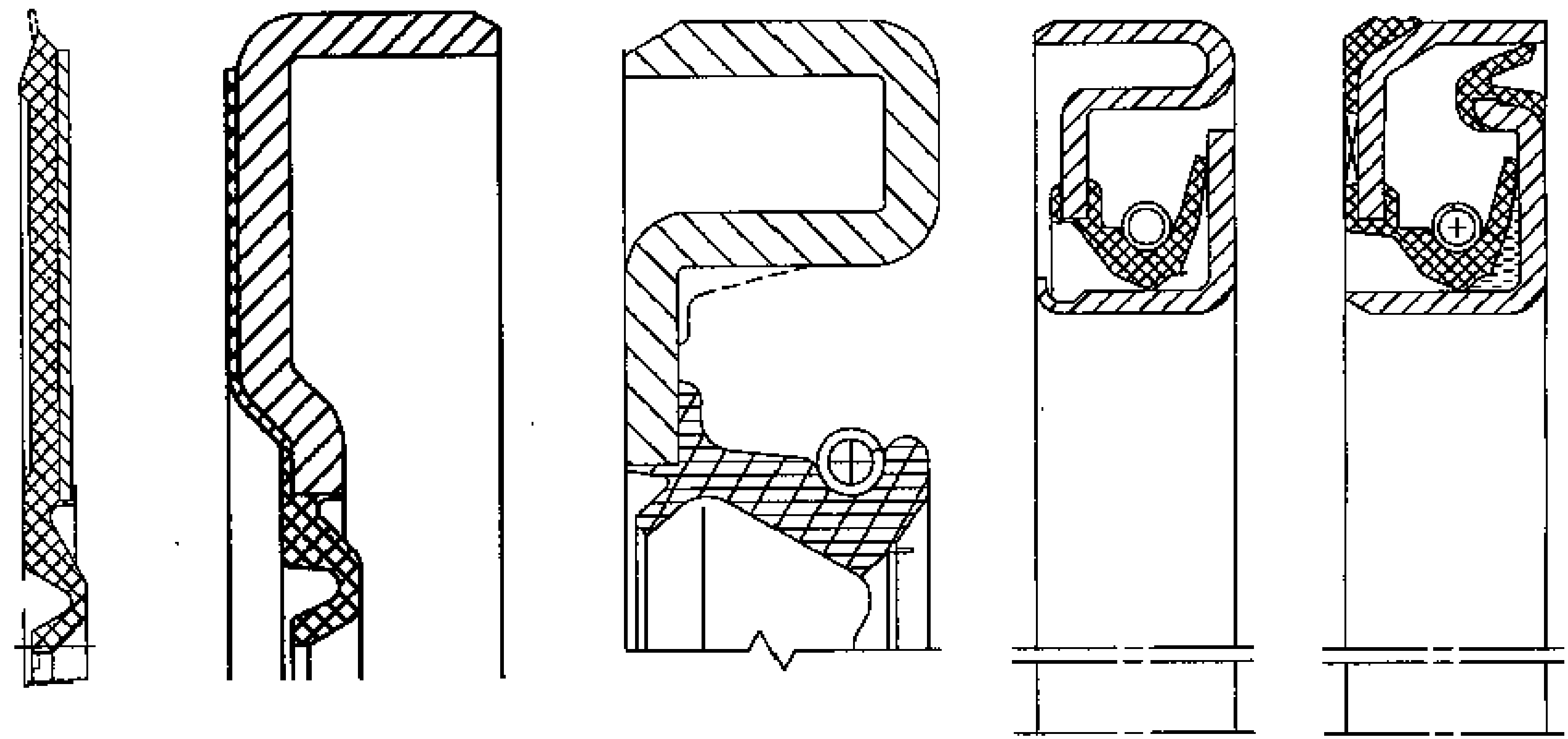


12 Aug 2002

SKF 001415

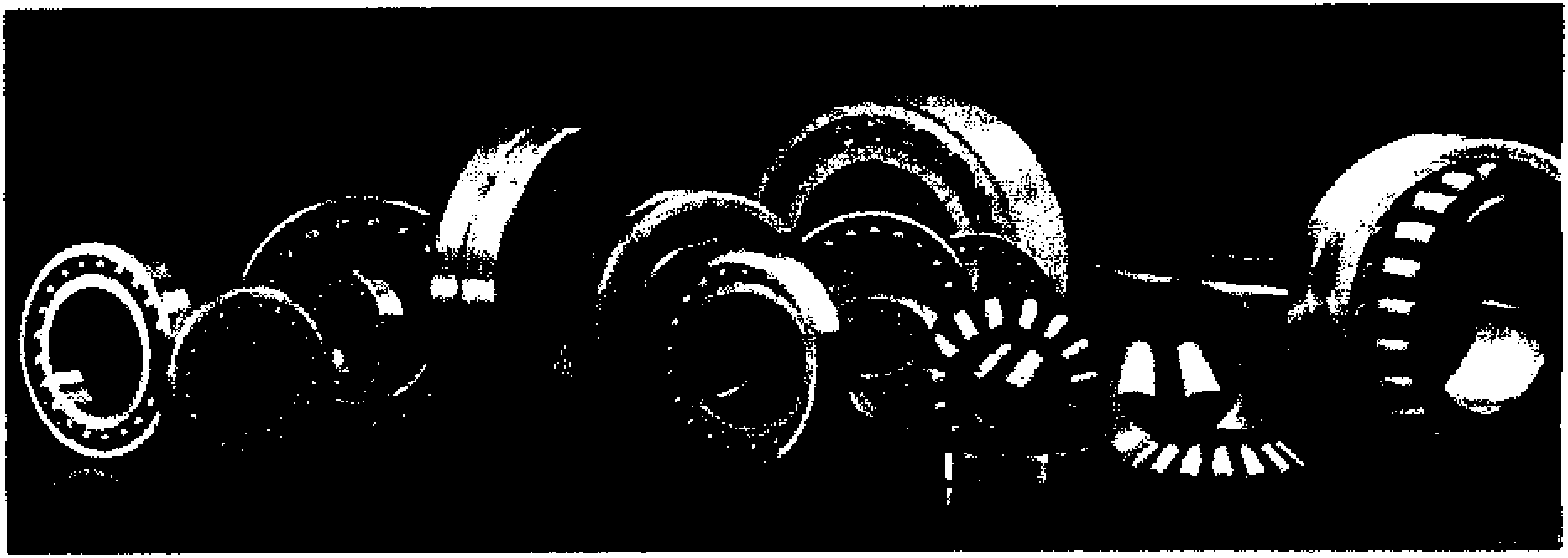
New Products

Seal Designs



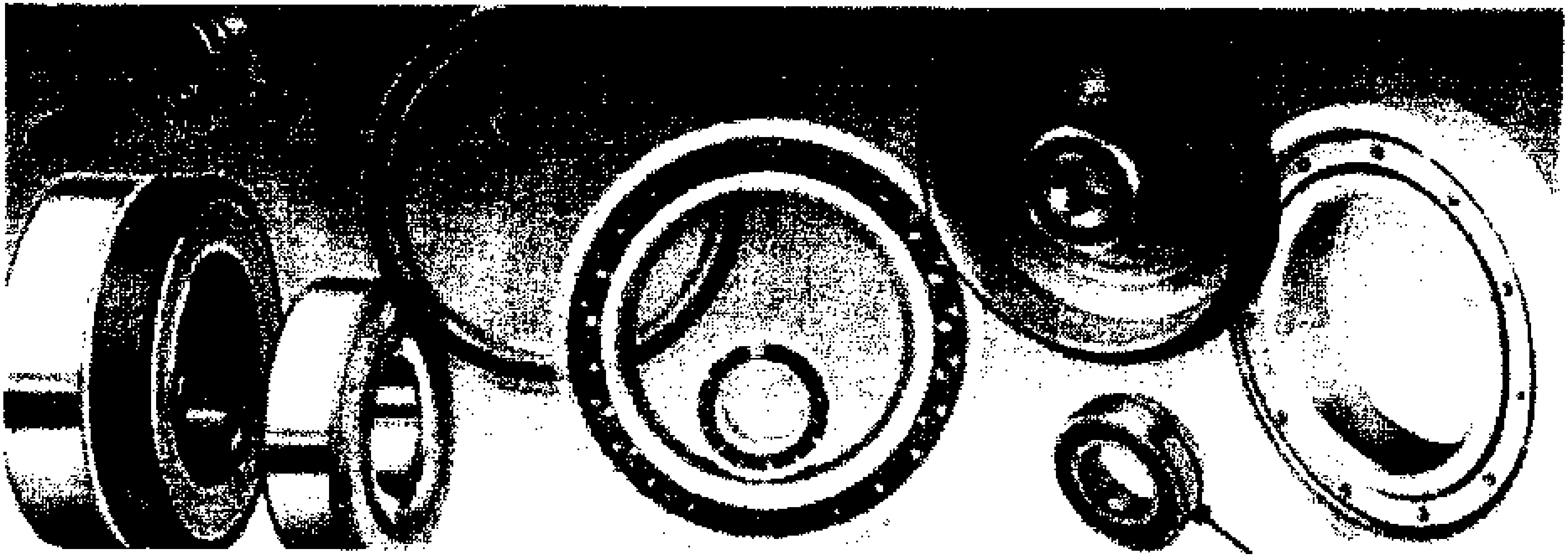
Lipseal | Lipseal | Garter-seal | R-Safe | R-Safe++

Products (1)



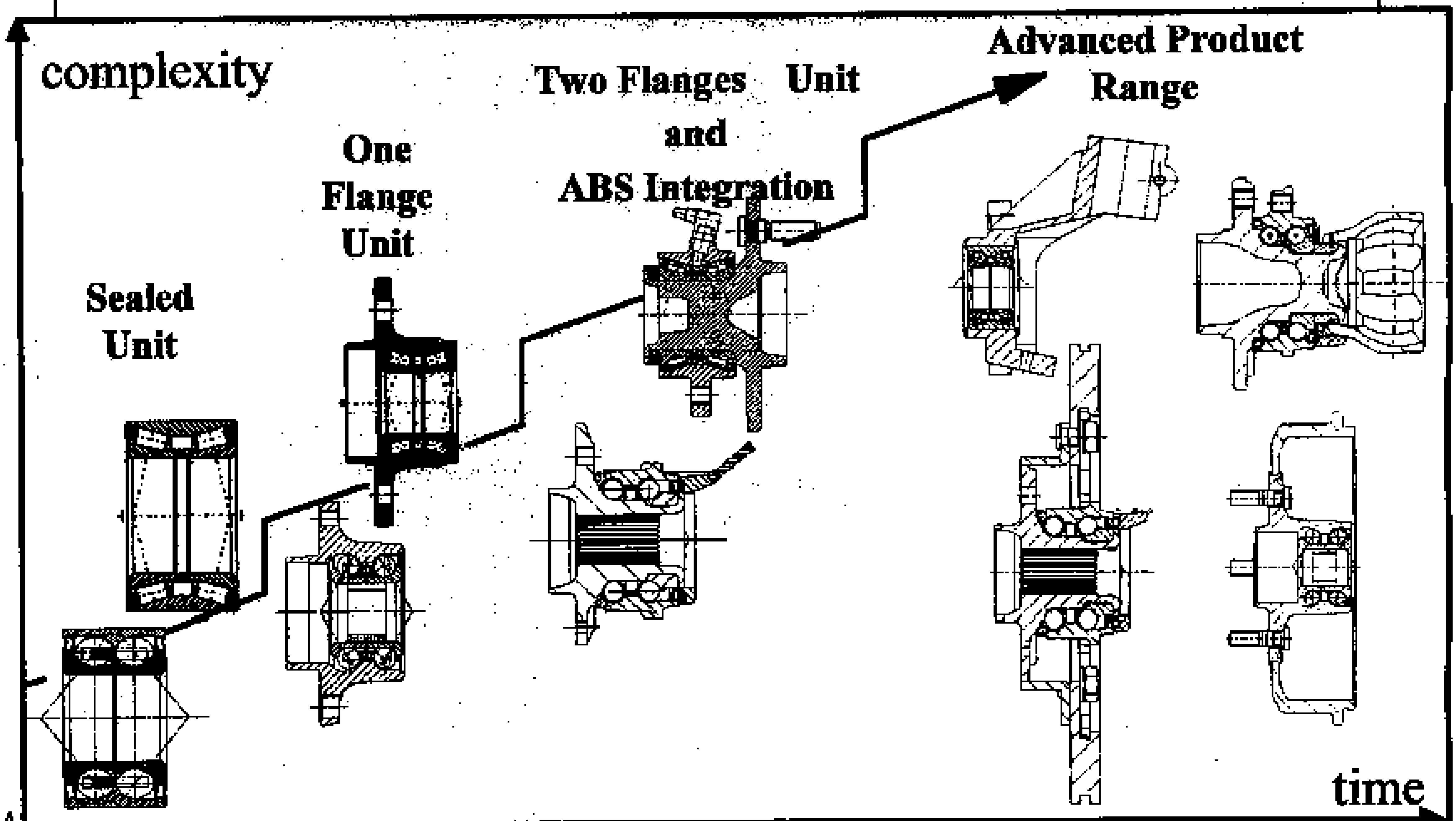
Deep groove ball bearings
Self-aligning ball bearings
Angular contact ball bearings
Cylindrical roller bearings
Toroidal roller bearings, CARB®
Spherical roller bearings
Taper roller bearings
Spherical roller thrust bearings
…… (and several others)

Products (2)



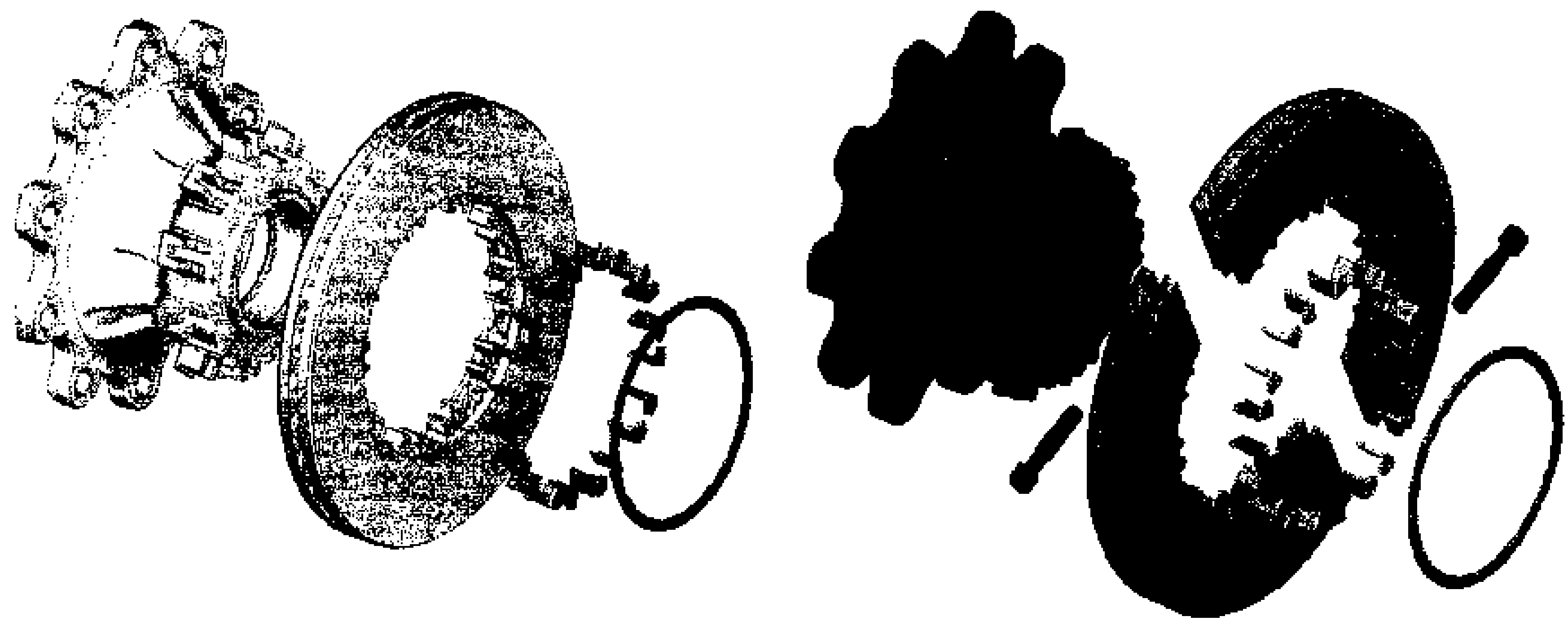
Smaller, lighter, tighter, faster, with built-in measurement systems, advanced seals and new materials.

Trucks to follow Cars



SKF 001420

Disk Brake



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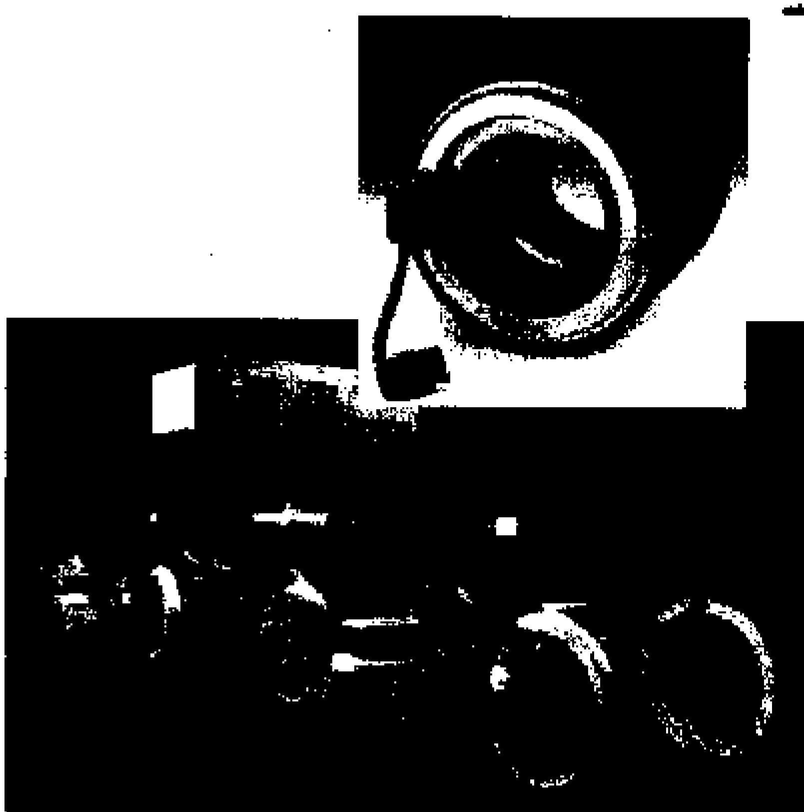
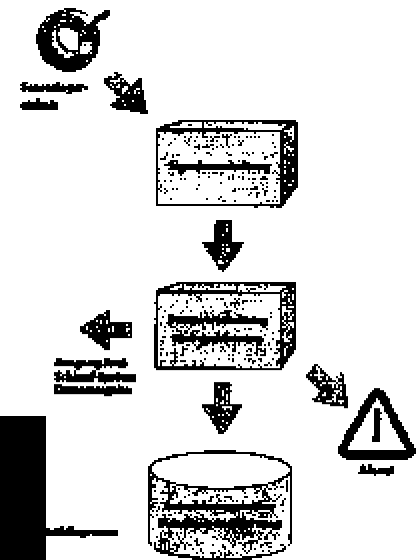
Bogie Monitoring System BoMo™



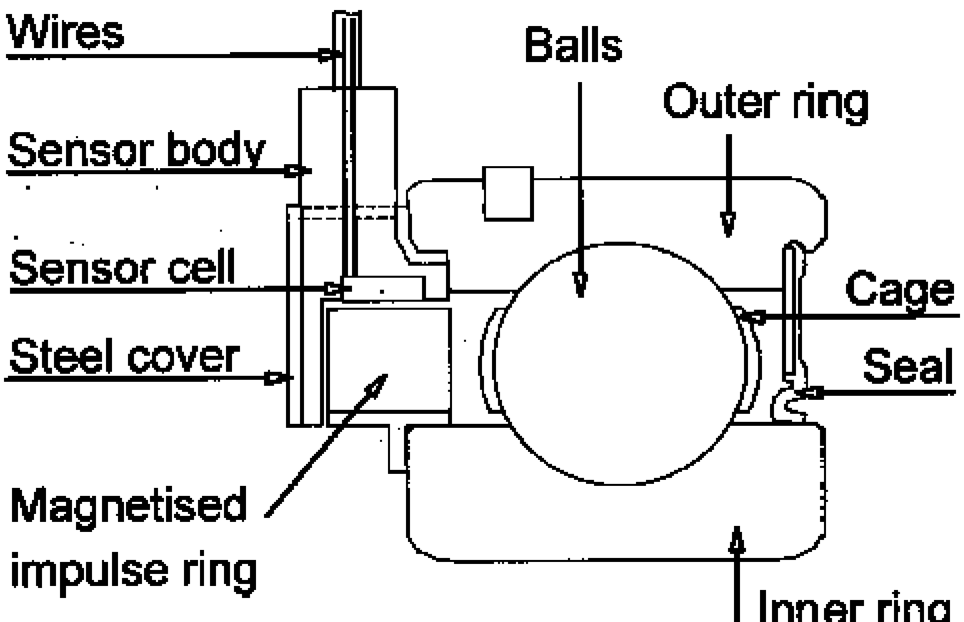


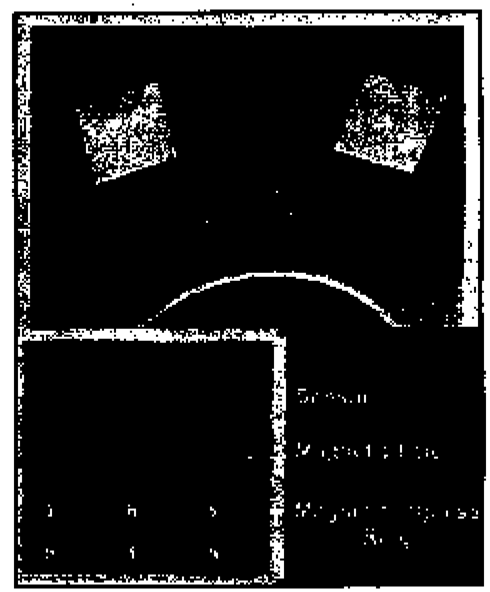
Measurement and recording to detect

- Bearing condition
- Wheel condition
- Bogie instability
- Derailment

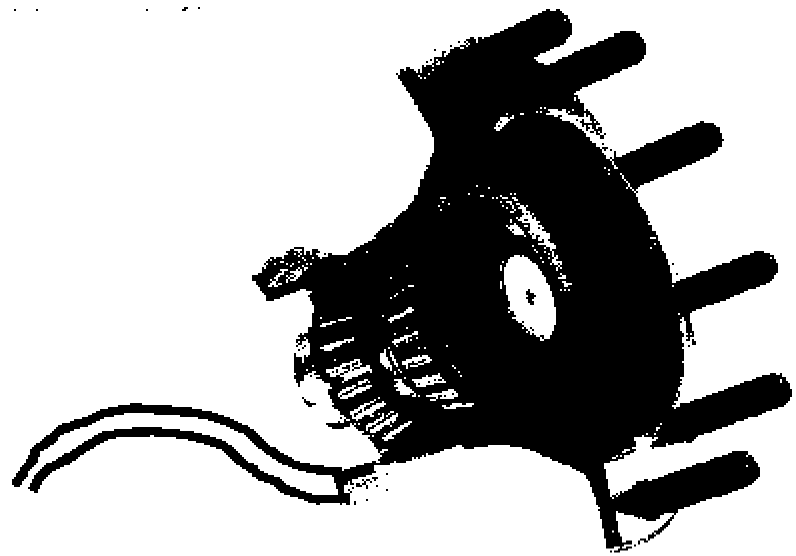
12 Aug 2002

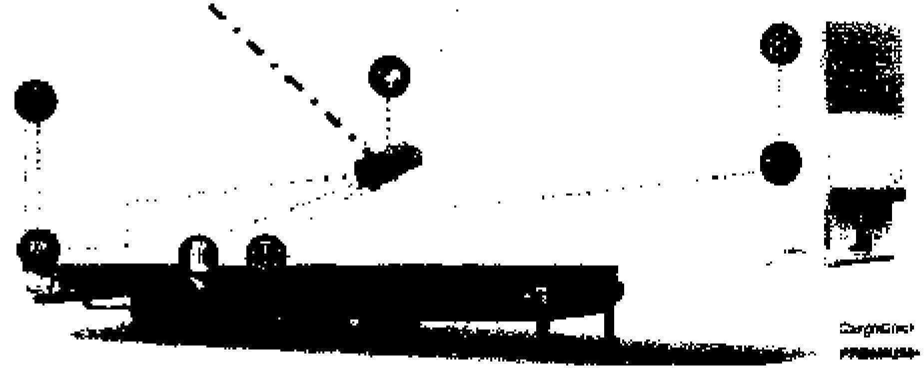
Sensor Bearings





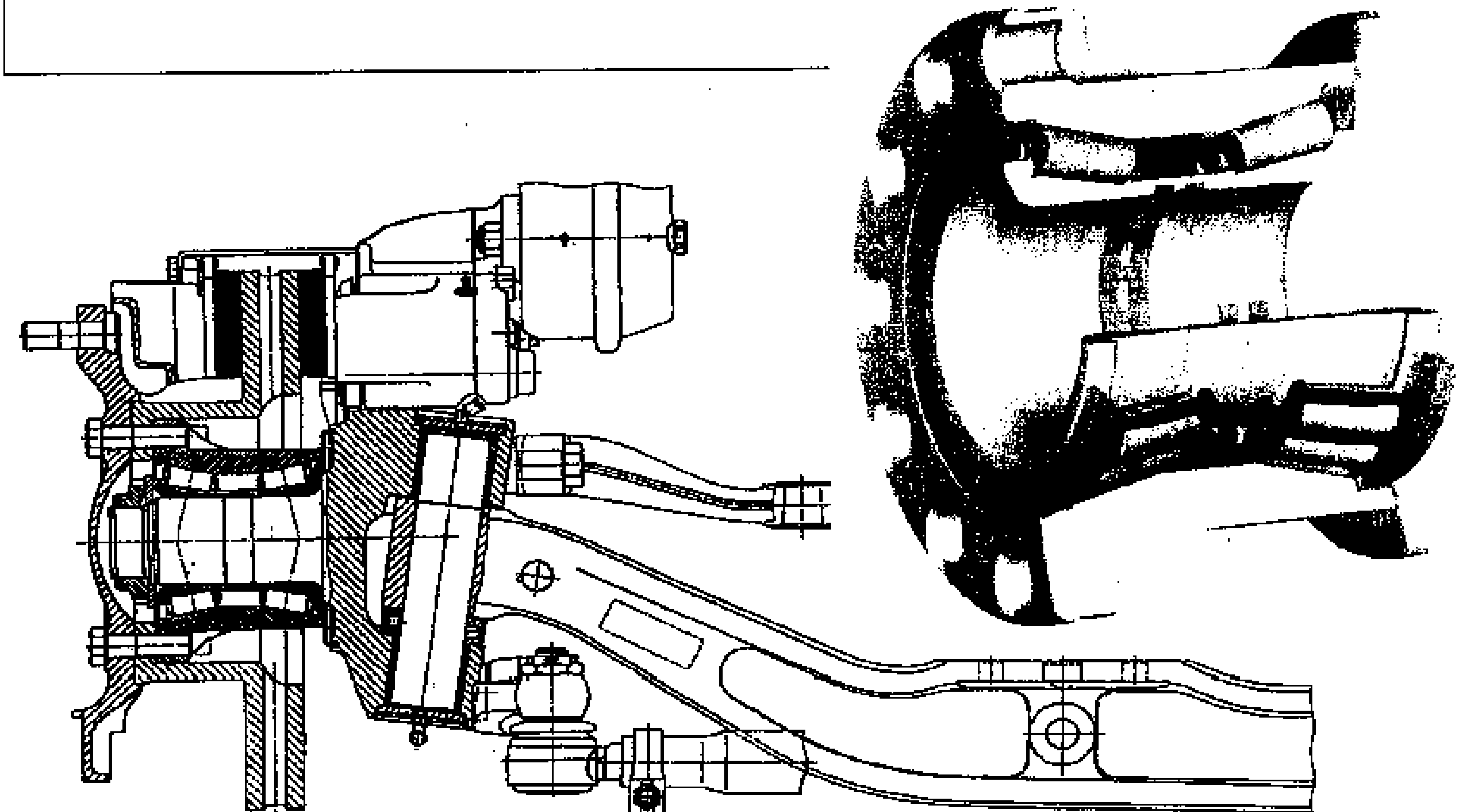
Erfassung, Speicherung und Übersendung von Ortungs- und Betriebsdaten





SKF 001424

Application Example



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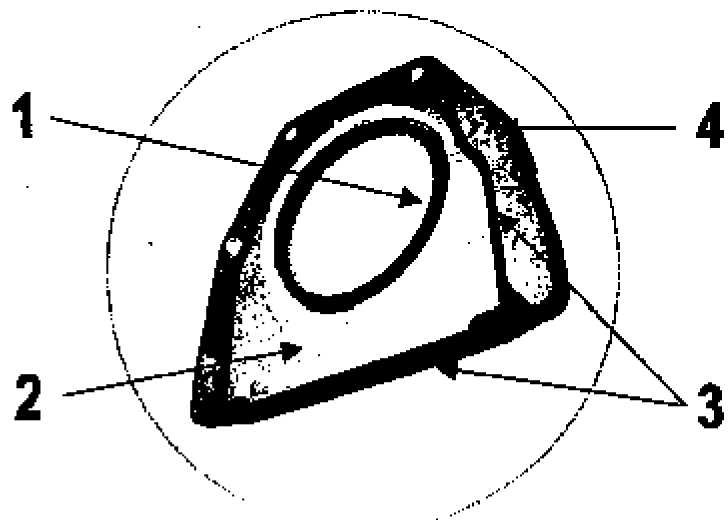
Rotostat

Total crankshaft sealing system consists of 1) dynamic shaft seal, 2) retainer, 3) static seal (gasket/sealant) and 4) dowel pins

FKM or PTFE Shaft Seal material



All-in-one component

Simplified assembling process

Optimal centering of dynamic seal

Advanced "elastomeric" static seal

Potential weight/cost reduction

One supplier to control sealing elements

Extensive production experience

12 Aug 2002

SKF 001426

SKF

Test Summary Steer

Date	Test	Summary
11july02	Big Ryder Springs Analysis	
24July02	Visual Inspection of Returned Inner Rings	
10July02	X-Ray Analysis From Field	
24-july02	Grease Analysis from Field	
24July02	Raceway Qualification Test "water in Grease"	
24July02	Air Leak Test on FF98X Knuckle	

SKF

Test Summary Steer

Date	Test	Summary
Ongoing	Bosch Proving Grounds	
Ongoing	Southwest Research	

12 Aug 2002

Aiken Quality Audit

A) Review and update of FMEA

B) Control of inner ring inspection and test records

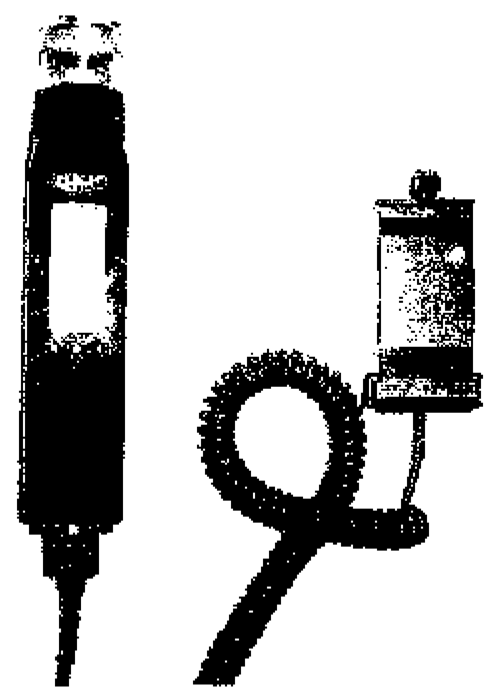
C) Robustness of supplier management

D) Lab access to controlled documents

E) Lot traceability

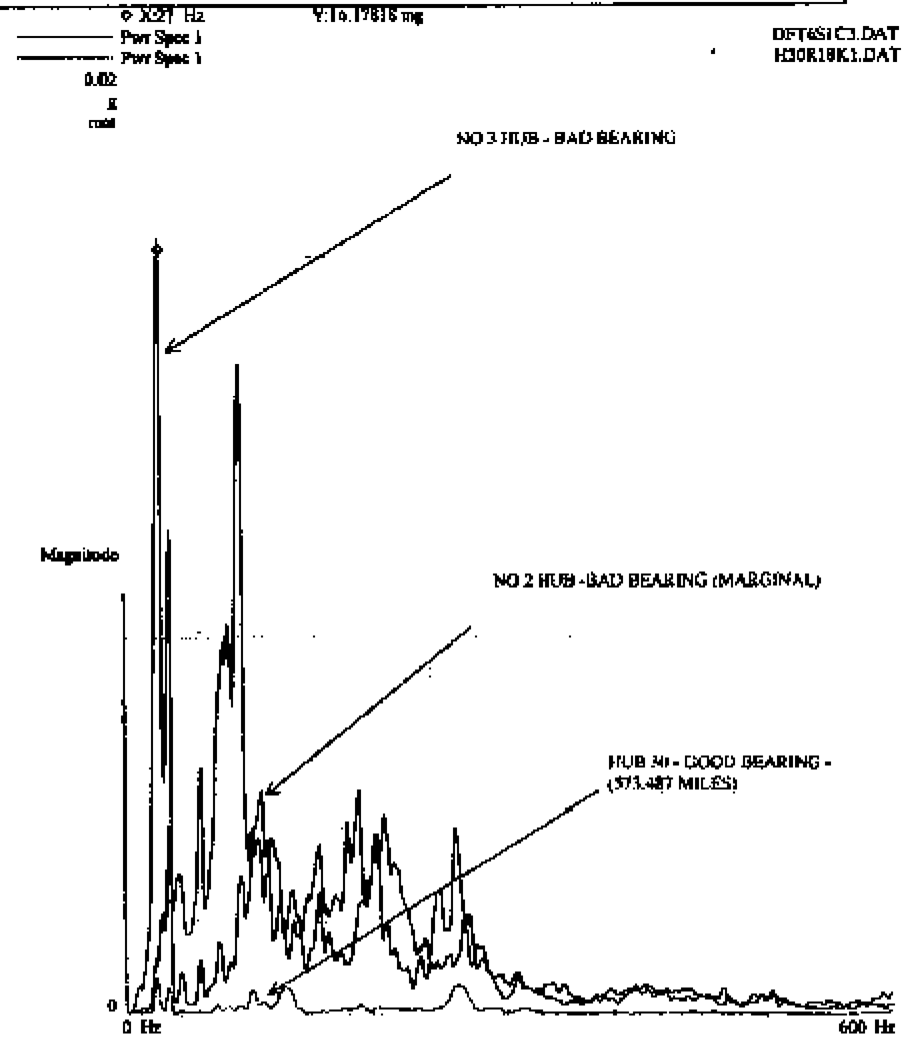
Vibration Pen

- Industrial unit exists
  - Used today for various industrial bearing monitoring applications
    - Used at operating speeds and loads
- Modifications required:
  - Increased gain
  - Lower electrical noise
  - Remote sampling switch and indicator lights
  - Other minor issues



Vibration Characteristics

- Shows differentiation good unit vs. damaged
  - Most activity in lower frequency ranges
  - Scale of readings is small



COMPARISON OF VIBRATION VIBRATION SPECTRUM AS MEASURED AT THE KINGPIN LOCATION

12 Aug 2002

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Vibration Pen Milestones

- Proof of concept
  - Evaluation of all devices
- Field trial evaluation – selection
  - Ryder 7/24 & 25
- Prototype revisions
  - 7/29
  - Mechanical assist device with tachometer
- Field Evaluation – scheduled to begin week of 8/12
  - 10 Production intent units by 8/9
    - Instruction sets
    - Procedures
- Evaluation of field trial data and feedback by 8/30
- Production release 9/10

Trailer update

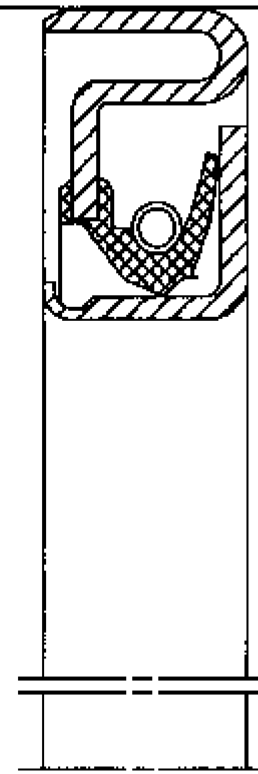
- 82 mm launch
- Annual Volume – 26,000 pcs/yr est
- 300 PPAP sample is in Crossville
- Waiting for a customer order from Carolton
- 40 axles to be built for field trials – 2 months

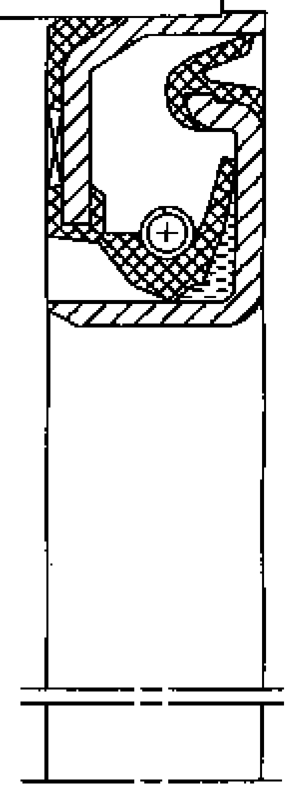
Trailer – Next Generation Seal

R-Safe + - 100 % viton

R-Safe + with 3rd lip in HNBR

Elimate Bruss seal ($7-$10)





90 mm THU-2

- THU will be axle as the new ATMU
- Timing 2 months THU-2
- Fitted with a shoulder seal
- Tests ongoing to validate R-SAFE +
- R-SAFE + will be a running change

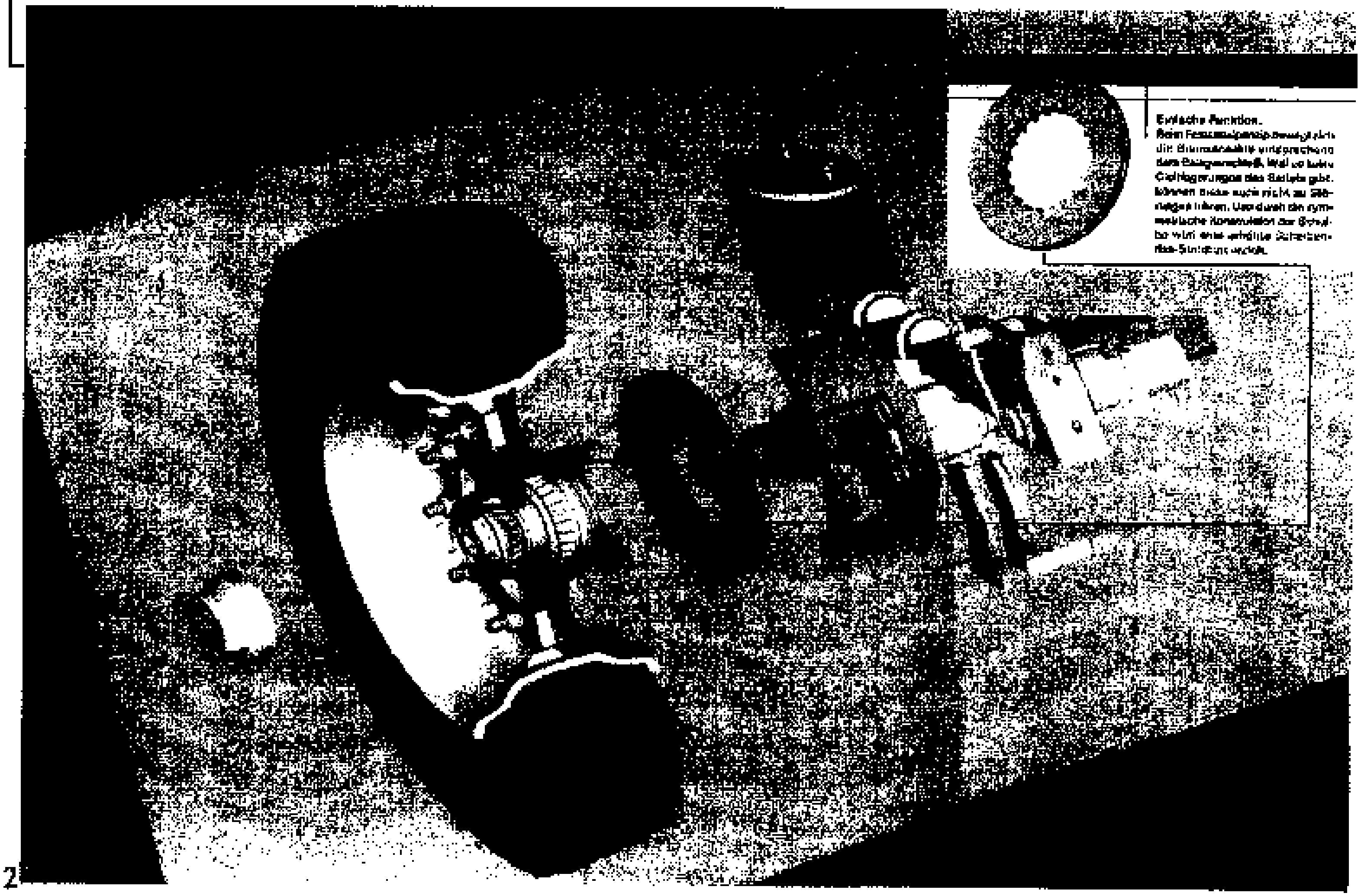
90 mm ATMU

- Finalizing Hub DWG
- RFQ's are being submitted
- Timing – December 2002

Pinion Seal Status

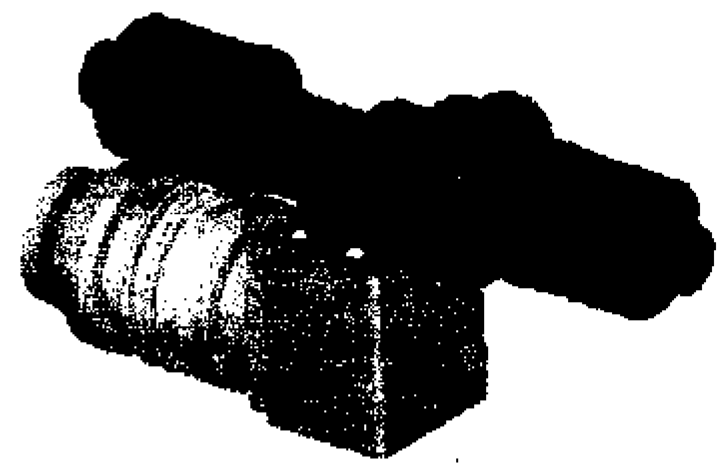
- One more iteration is being developed

Brake - by- wire



Steer-by-Wire

-Rear steer-by-wire system for SUV/light trucks with independent rear suspension



-Fully electromechanical solution with local power and control electronics

-SKF system included in IRS presentations made recently by ArvinMeritor to OEMs

-Specific OEM customer vehicle program is the next step in significant further rear steering system activity.

What is SKF doing for ARM

12 Aug 2002

SKF

Quality,Delivery etc

Studs Status

12 Aug 2002

Ingersol Stud Status

PO for Phase 1 Fatigue Tests -	Complete 31 Jul
Phase 1 Bending Fatigue Test	Complete 31 Aug
Review Results with Ingersoll	Complete 7 Sep
Phase 2 Bending Fatigue Tests Determine Final	
Engineering Tolerance for Surface Hardness	Complete 7 Oct

SKF 001445

Studs – Lake Erie Validation

12 Aug 2002

Commercial Discussion

Payment Terms

15th Ultimo Special

73 –78 days , 15 th ultimo special s/b 65 days
Your writing a cheque on 25th
We're getting the cheque on the first week of the following month

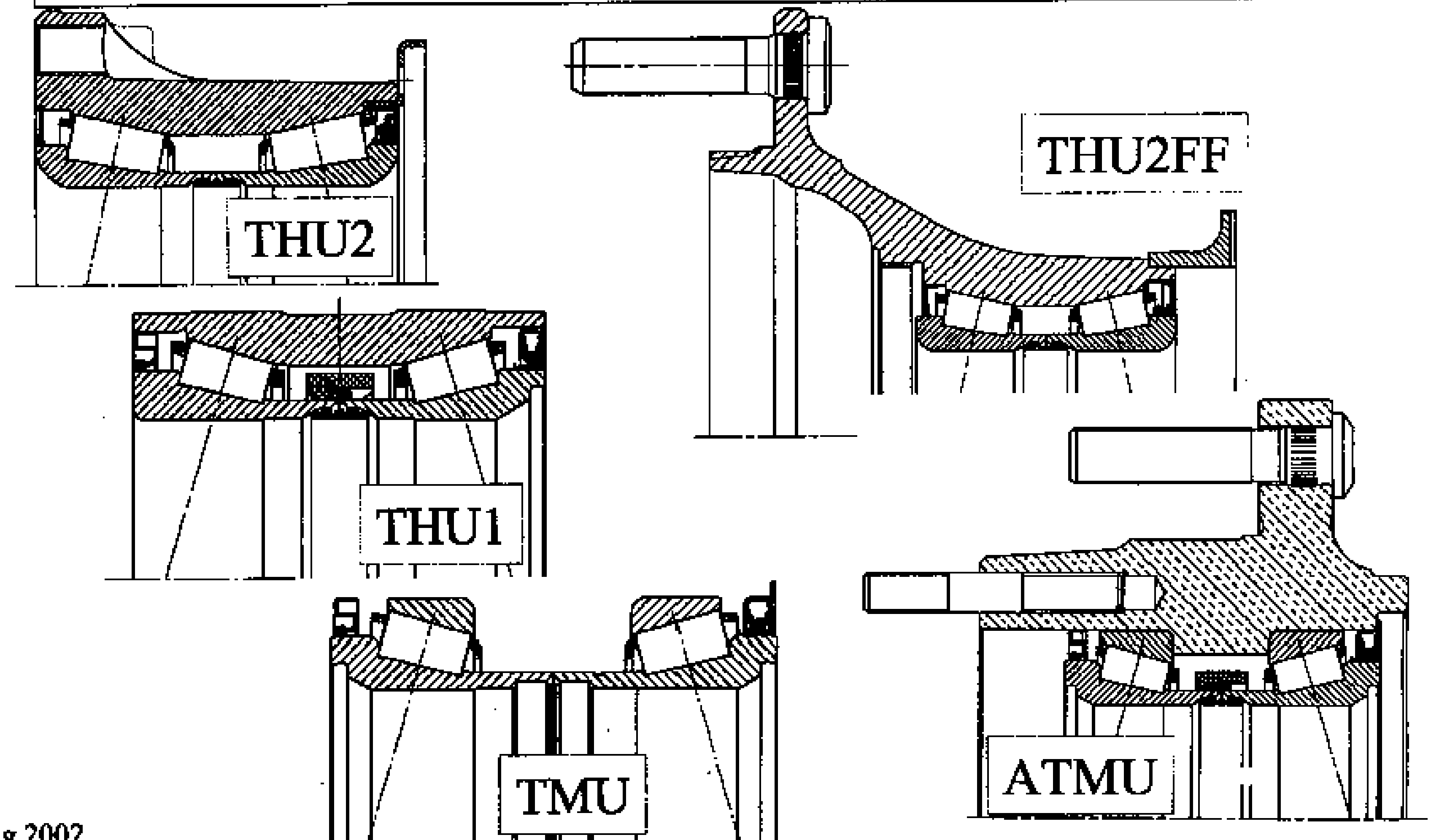
Average dollars – 300 -500 k

This is costing SKF $2000 month approx

European cost reduction Activities

- TPU
- Aftermarket Parts
- Lindesbury cost reduction activity
- RFT Seal status

Unitized Wheel Ends



12 Aug 2002

Freightliner Summary

Conclusion:

- **Based on the implemented product & process enhancements the FF-981 axle will meet all original design life expectations.**

- **The original inspection procedure will be reinstated with the launch of the New Hubcap – November 2002**

The Next Steps:

- Continued communication with fleets regarding PM intervals
- Evaluate the need for communication to drivers
- Inspect a representative sample of 500 Trucks with an electronic diagnostic tool.
  - To confirm the health of the population.
  - To focus on the 3 spike periods described herein

Timing:

- 60 Days to conduct Inspection; 30 days for Analysis

Steer THU

- June 1999 – Hub Thread and cap process improvements resulting in 100 % conformance.
- April 2000 - Changed to GWZ Grease & R-Safe Seal
- June 2000 - Corrected Heat Treat Reject System
- June 2000 – Axial Clearance Redesign
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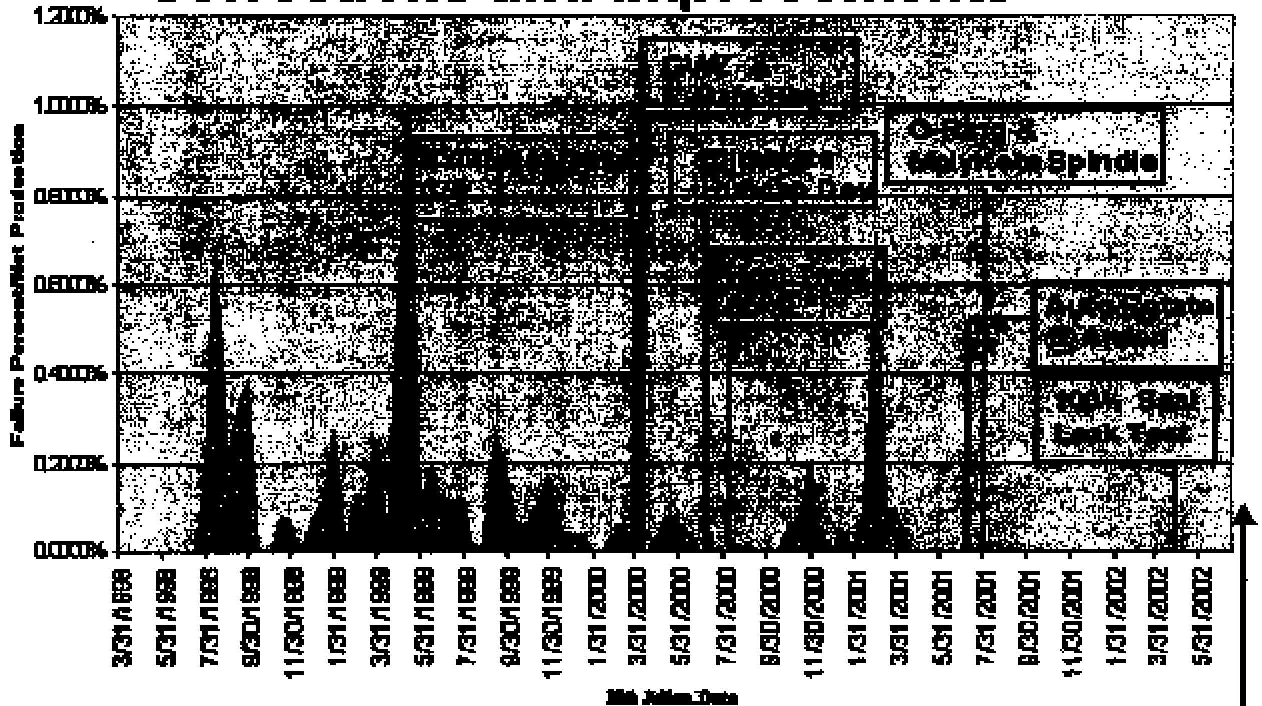
- April 2002 – 100% Seal Leak Test At Elgin
- Nov 2002 – New Hub Cap Design

SKF Allen Failure Rate Based on Hub Julian Dates

Corrections and Improvements



New Hubcap Design in November 2002

12 Aug 2002

SKF

Test Summary Steer

Date	Test	Summary
09Jul02	Air leak Test	
19July02	Supplemental Air leak Test	
06Jun02	Air Leak test on ARM knuckle	
09Jul02	Assembly Test	
12 Jul02	Raceway Qualification Test	
17Jul02	Raceway Qualification with contaminated Grease	
17Jul 02	Stud Assembly Test	
24Jul02	Outboard Outer ring spalls	
26Jul02	Static Water Splash Test	
17May02	X-Ray Diffraction Analysis	
30May02	Seal wear study	
06Jun02	Man 1,000,000 km Axle	
06june02	Spindle Comparison Study	

Cover

12 Aug 2002

- SKF
- Business in General
- Market Trends
- Strategies
- Long Term Goals
- What SKF is doing For ARM

- Steer THU discussion?

12 Aug 2002

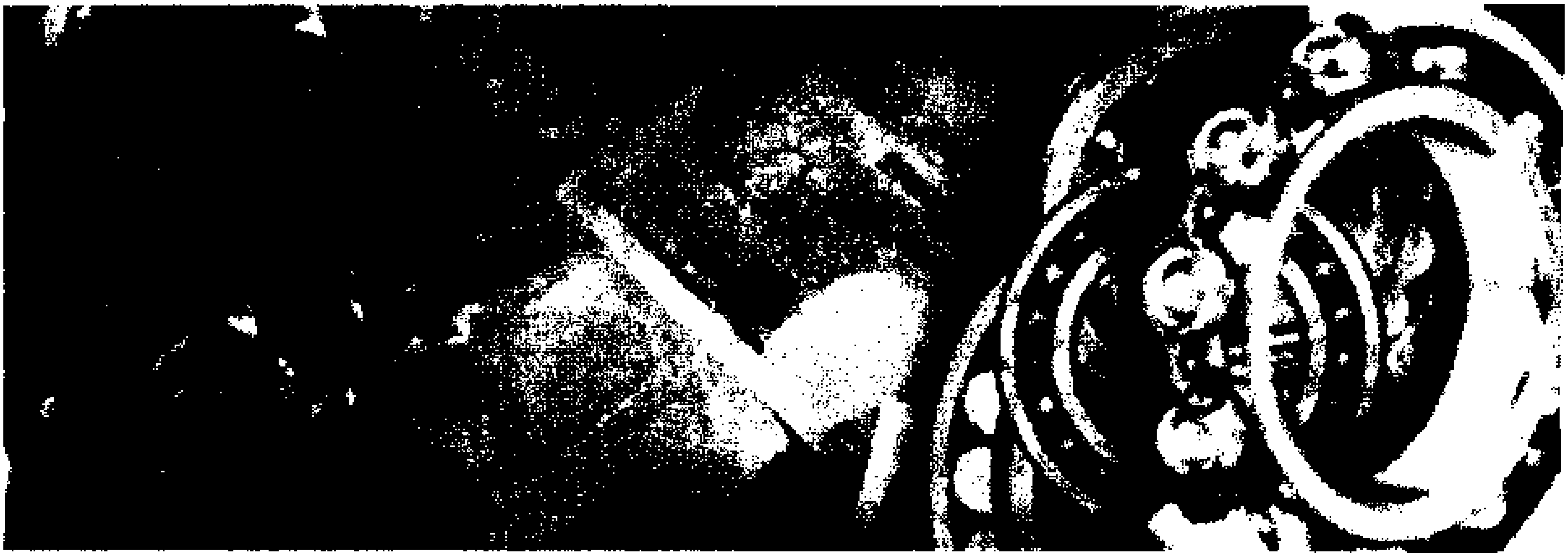
SKF

Objective

Annual Key Data

Net sales	43 370	39 848	+8.8%
Operating profit	3 634	3 674	-1.1%
Profit before taxes	3 120	3 002	+3.9%
Net profit	2 167	1 962	+10.5%
Earnings per share, SEK	19.04	17.23	
Cash flow	4 271	2 880	+48.3%
ROCE	14.9%	16.2%	
Reg. no of employees	38 091	40 401	-5.7%

One out of five is an SKF bearing

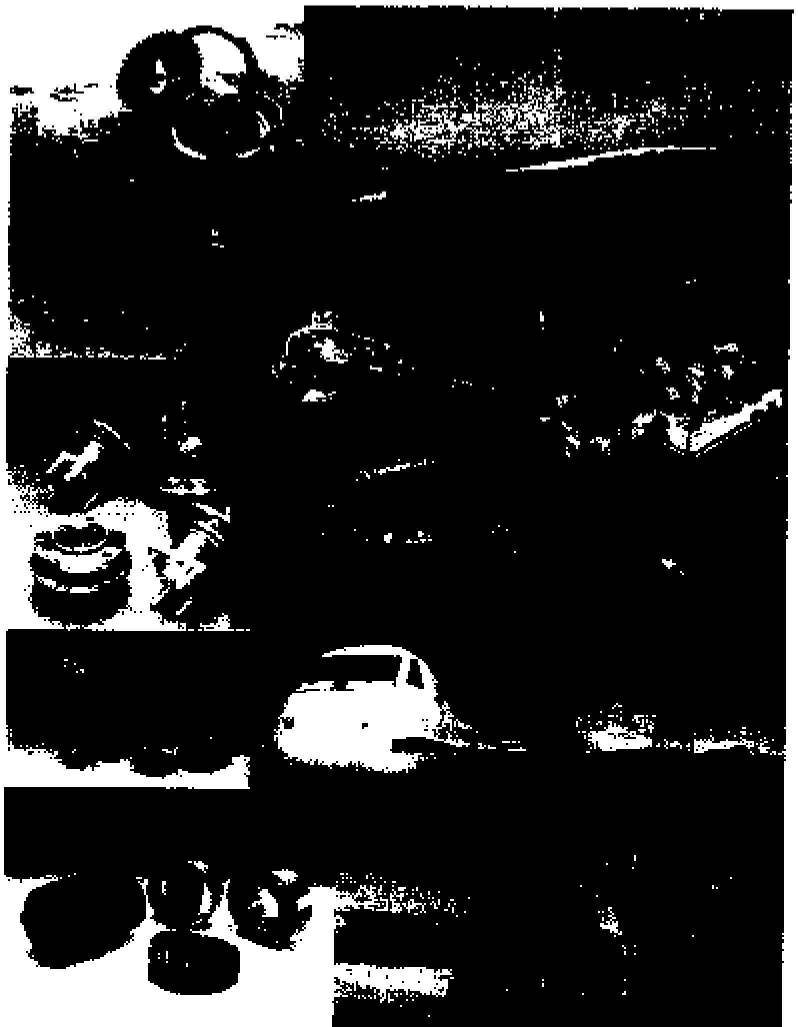


- 38 091 employees
- MSEK 43 370 annual turnover
- 80 production facilities in 22 countries

12 Aug 2002

SKF

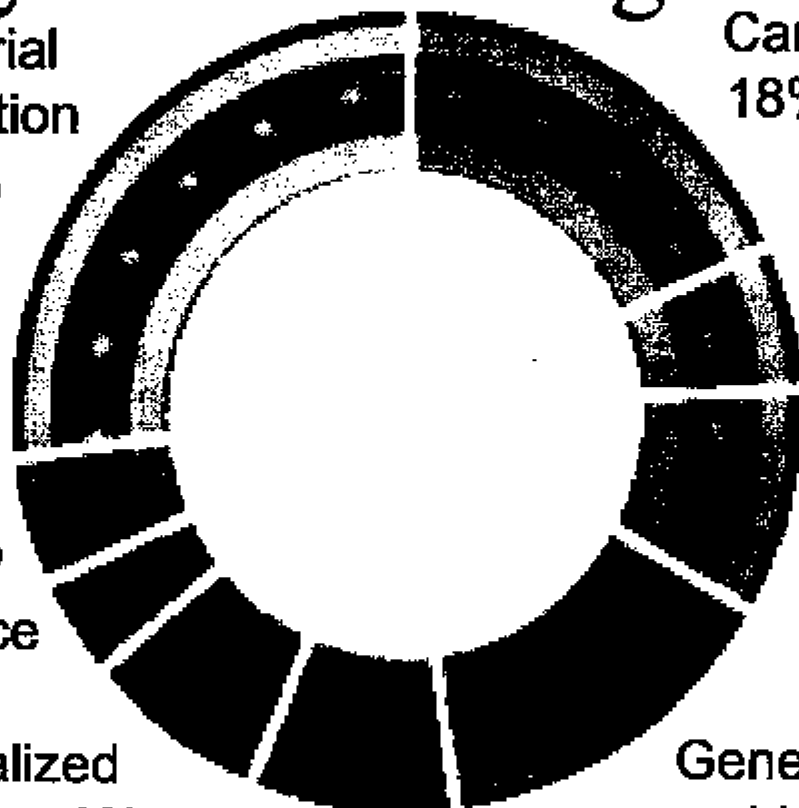
Key Technologies



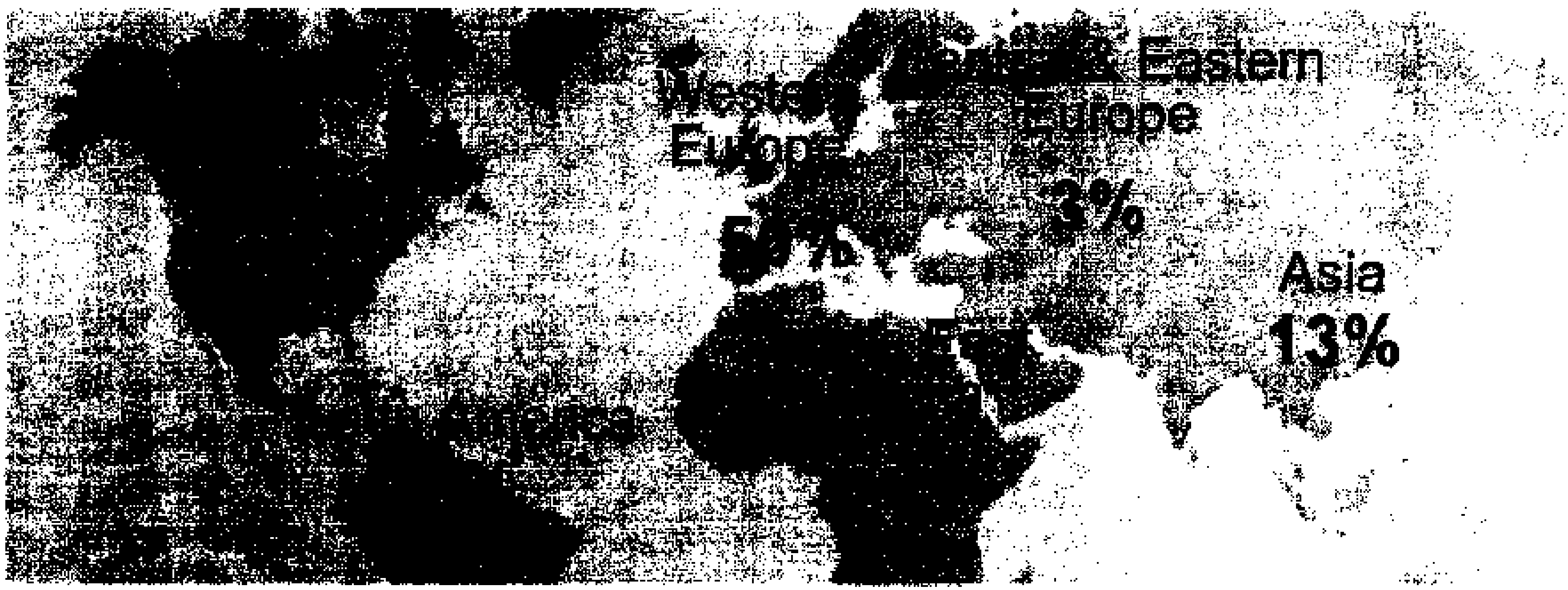
- Materials - steel / ceramics / polymers / elastomers
- Coatings
- Lubrication
- Manufacturing Technologies
- Mechatronics
- Noise & Vibration / System Dynamics
- Analytical Modelling
- Experimental Testing

SKF Group

Sales by customer segment 2001



SKF Group
Sales by geographical area 2001



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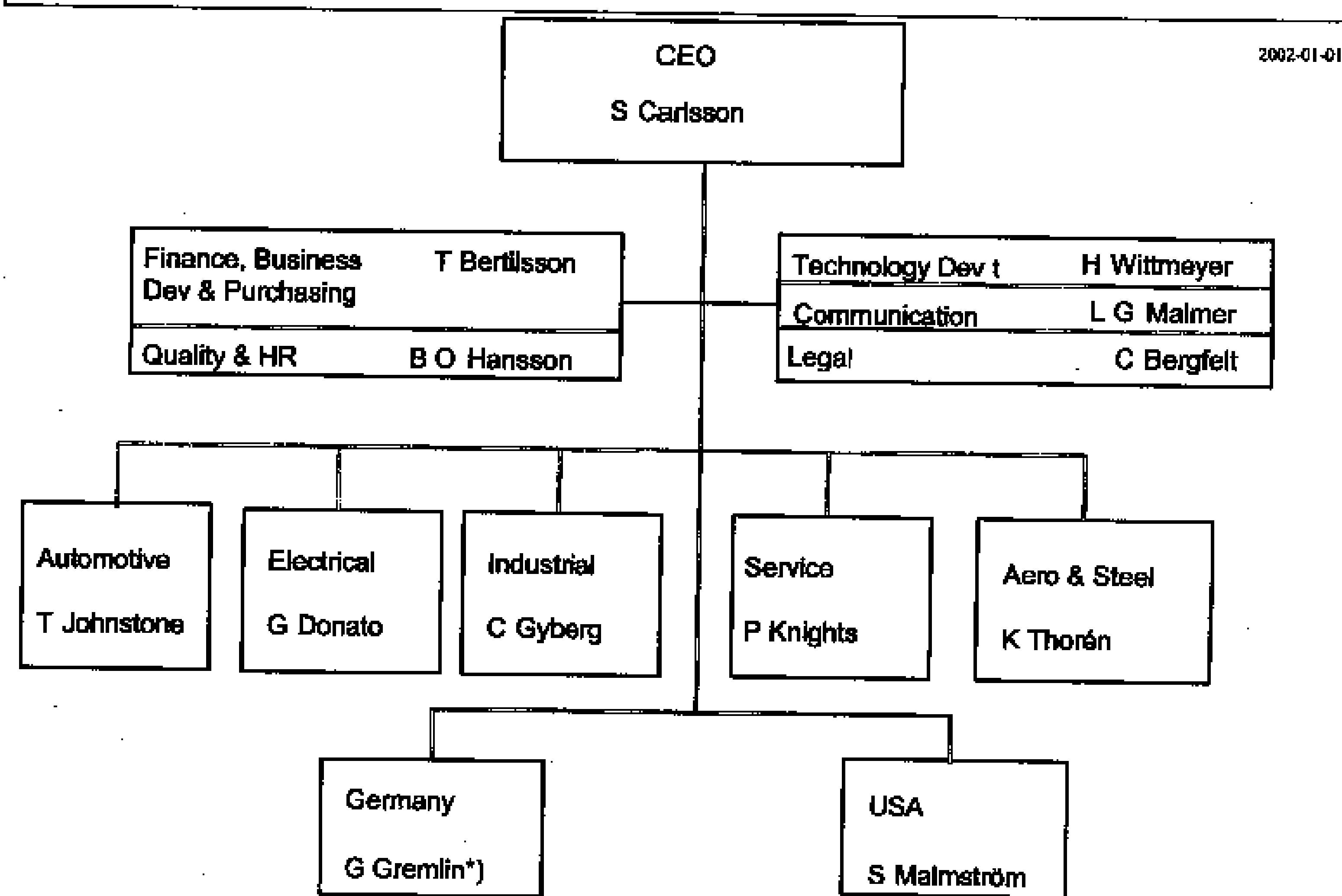
SKF 001464

SKF Group Organisation



*) Also responsible for Group IT

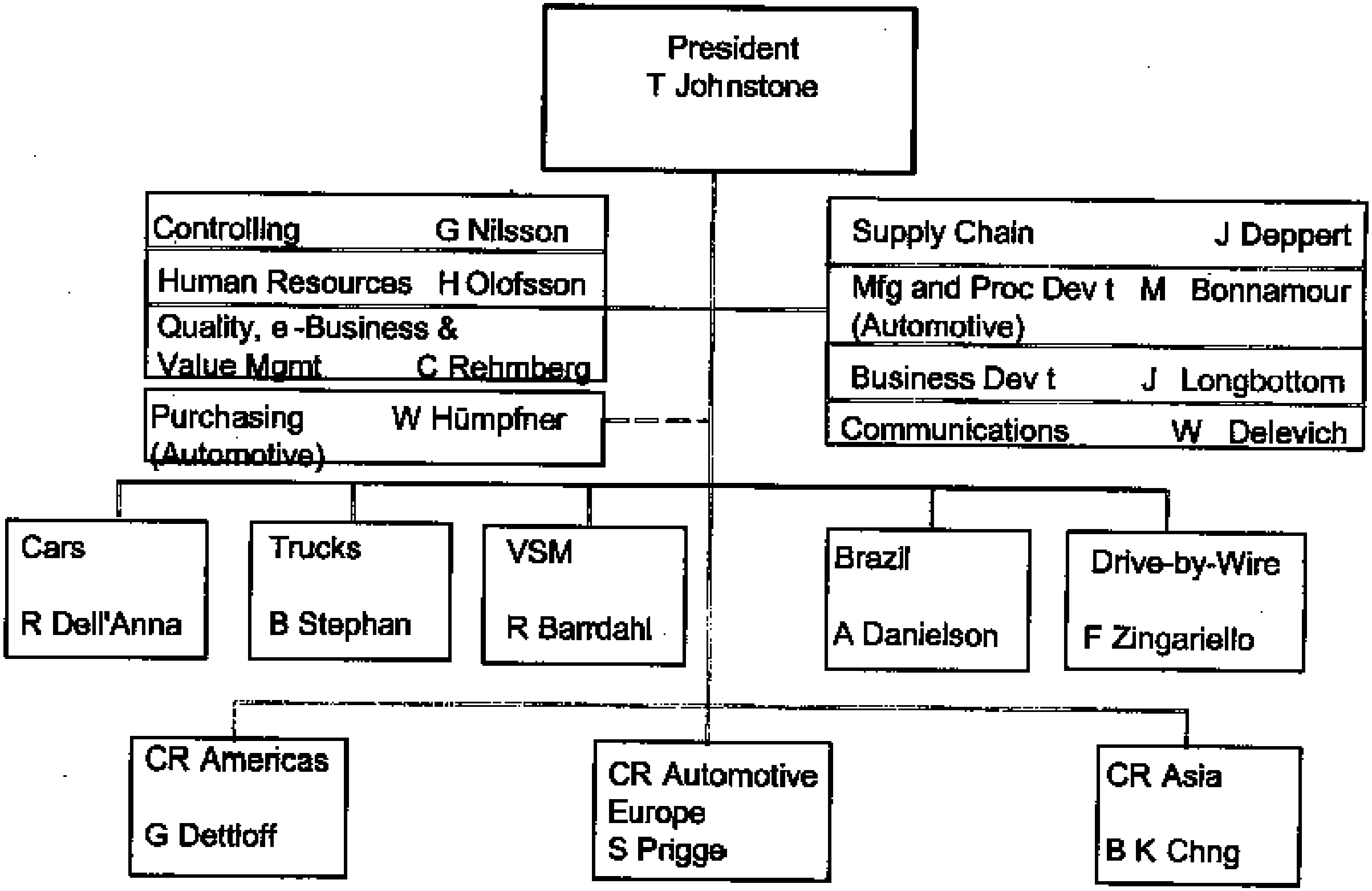
12 Aug 2002

Strategy

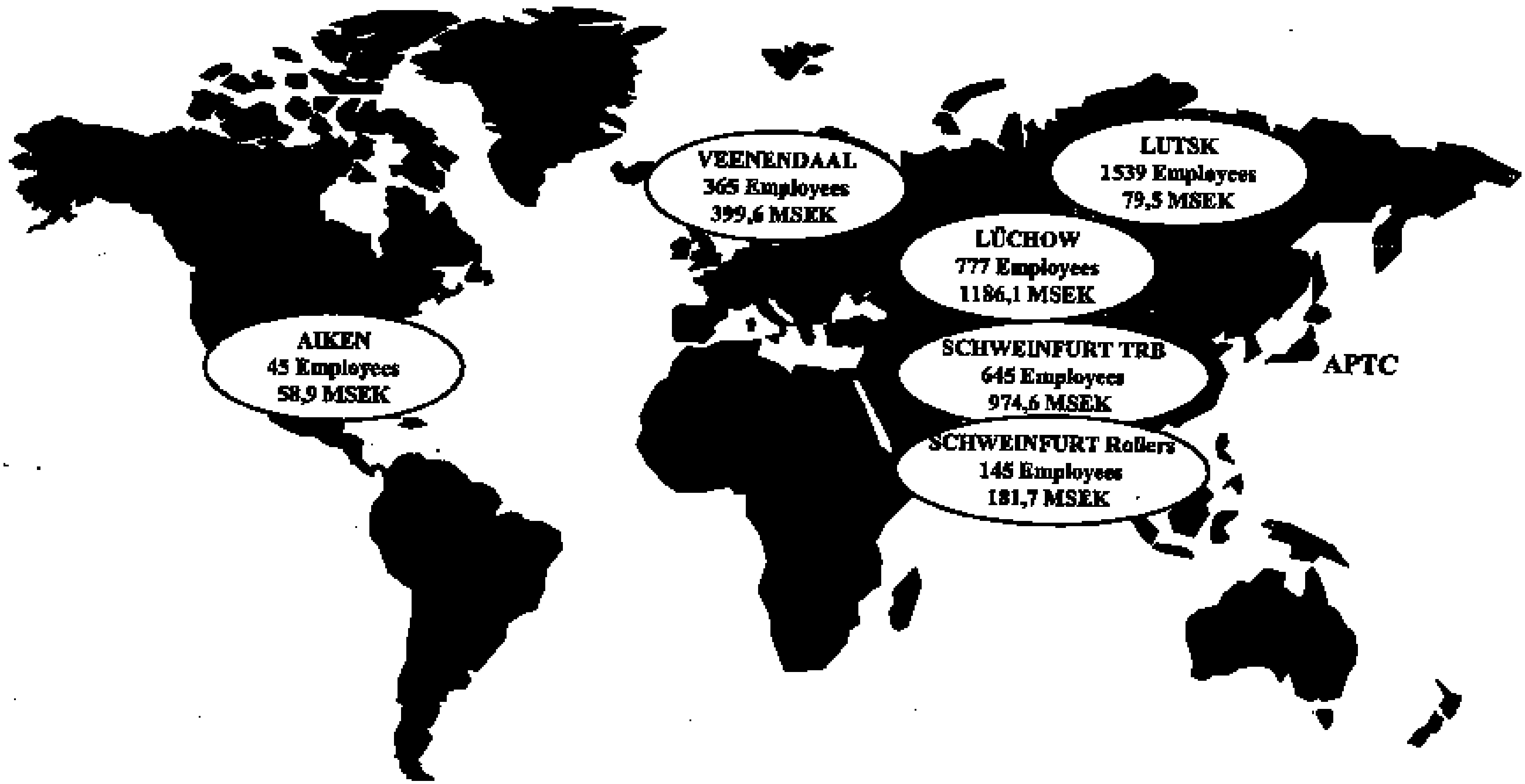
-	+
• Steel	• Service
• Components	• Trading
• Internal services	• Electronics
	• Partnership

12 Aug 2002

Automotive Division



BU Trucks worldwide



12 Aug 2002

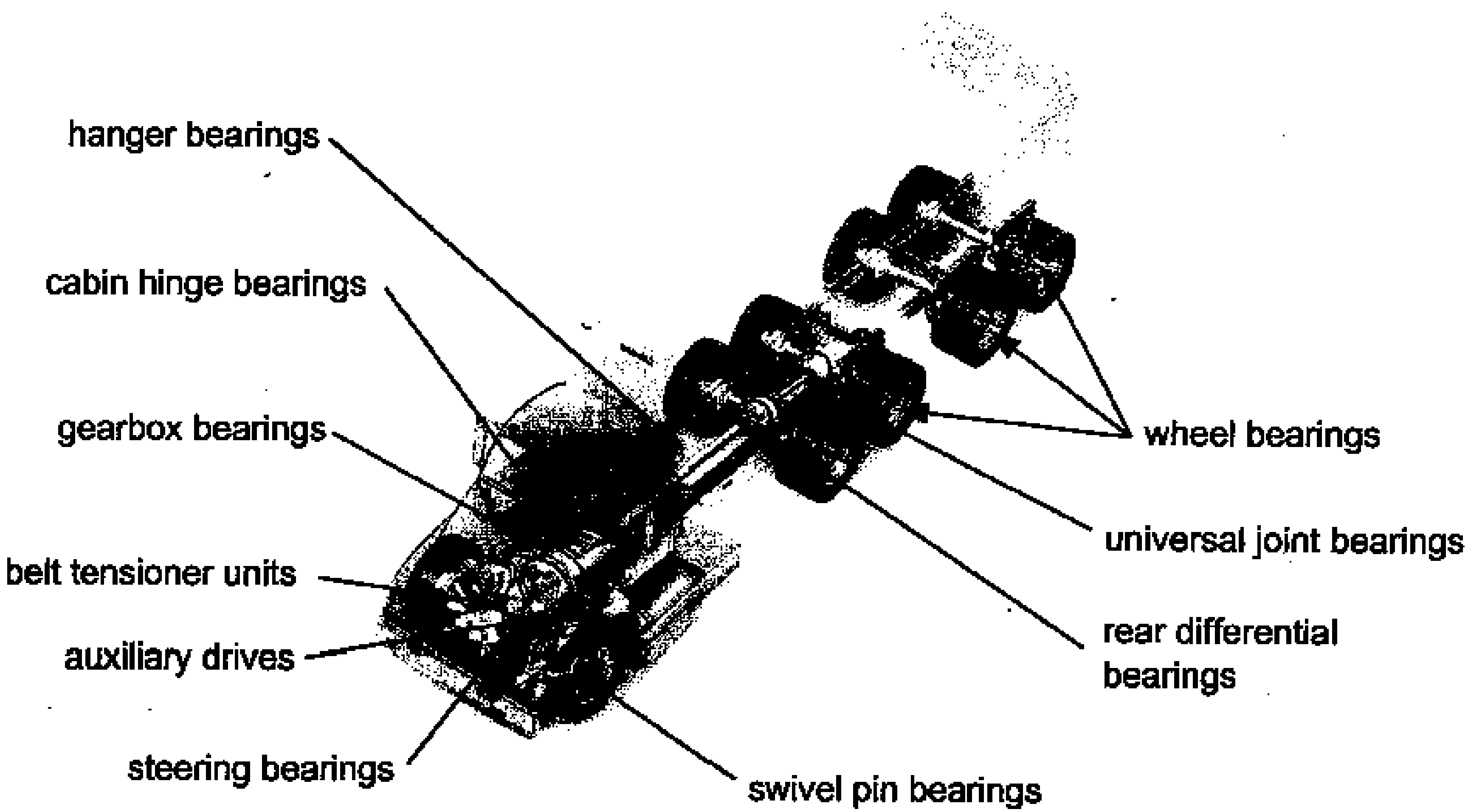
BU Trucks Organisation

- **Bernd Stephan** — Director, Trucks BU, SKF Automotive Division
  - **Armin Klatt** — Controlling, Trucks BU
  - **Jörgen Schultheis** — Quality, Trucks BU
  - **Mats Robertsson** — SKF Coordinator LBP, LBP Finance&Admin, Lutsk (UA)
  - **V.Tsybulsky** — MD LBP, LBP Sales East Europe, Lutsk (UA)
  - **Torsten Nordgren** — Manufacturing, Trucks BU
    - **Michael Kummert** — Plant Manager, TWL, Lüchow (D)
    - **Dr.J.Sommer** — Plant Manager, TWS,TWS-R, Schweinfurt (D)
    - **Joop Voorthuisen** — Plant Manager, Rollers&Cages, Veenendaal (NL)
    - **Volker Müller** — LBP Technology & Manufacturing, Lutsk (UA)
    - **Dr.M. Ciner** — Manufacturing Dev., Truck BU
    - **Ed Cotter** — Plant Manager, Aiken (USA)
    - **N.N.** — ABU India, Pune (India)
  - **Bill Farrell** — Sales USA, Mexico, Canada
  - **Thierry Borniche** — Sales West Europe, Latin America
  - **Matthias J. Haupt** — Business Development, TRB marketing, Sales Asia
    - **Karl Steinbeck** — TRB marketing, ID,SD,ED sales support
  - **Arno Stubenrauch** — R&D, Application Engineering, Trucks BU

12 Aug 2002

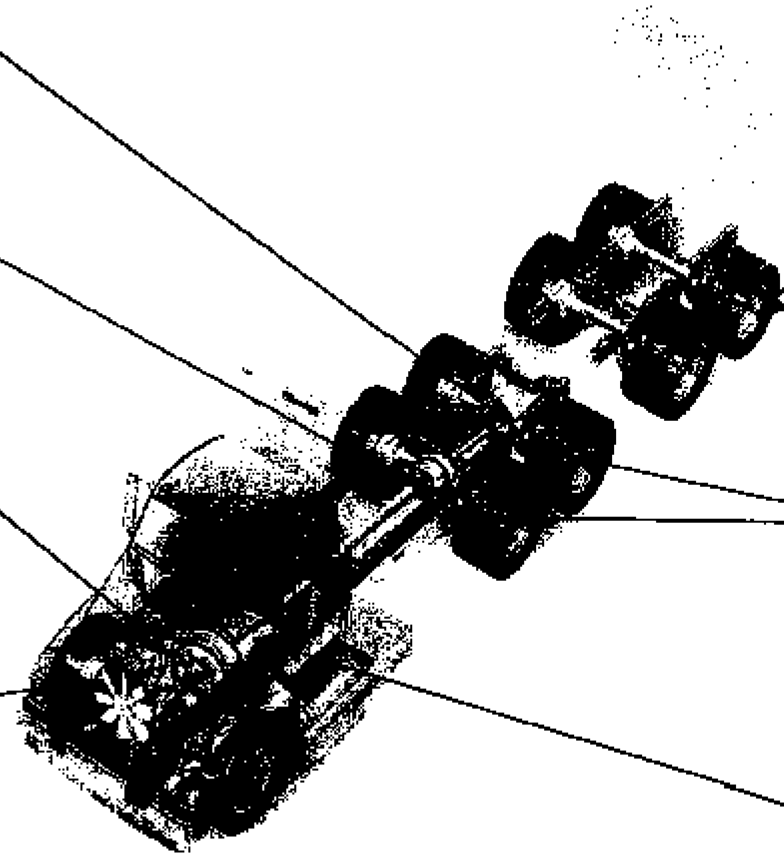
SKF

Bearings in Trucks



12 Aug 2002

Seals in Trucks



Discussion

Main Topic

Robert J Bondy/DET/SKF
08/02 11:18 AM

Subject: Final Freightliner Presentation Given on 01Aug02

Category: Information

ARMvibmaterial.pp Ftl072902 sales portion.p Progression.ppt

Bearing Condition Evaluation Device

August 1, 2002
Freightliner

ArvinMeritor

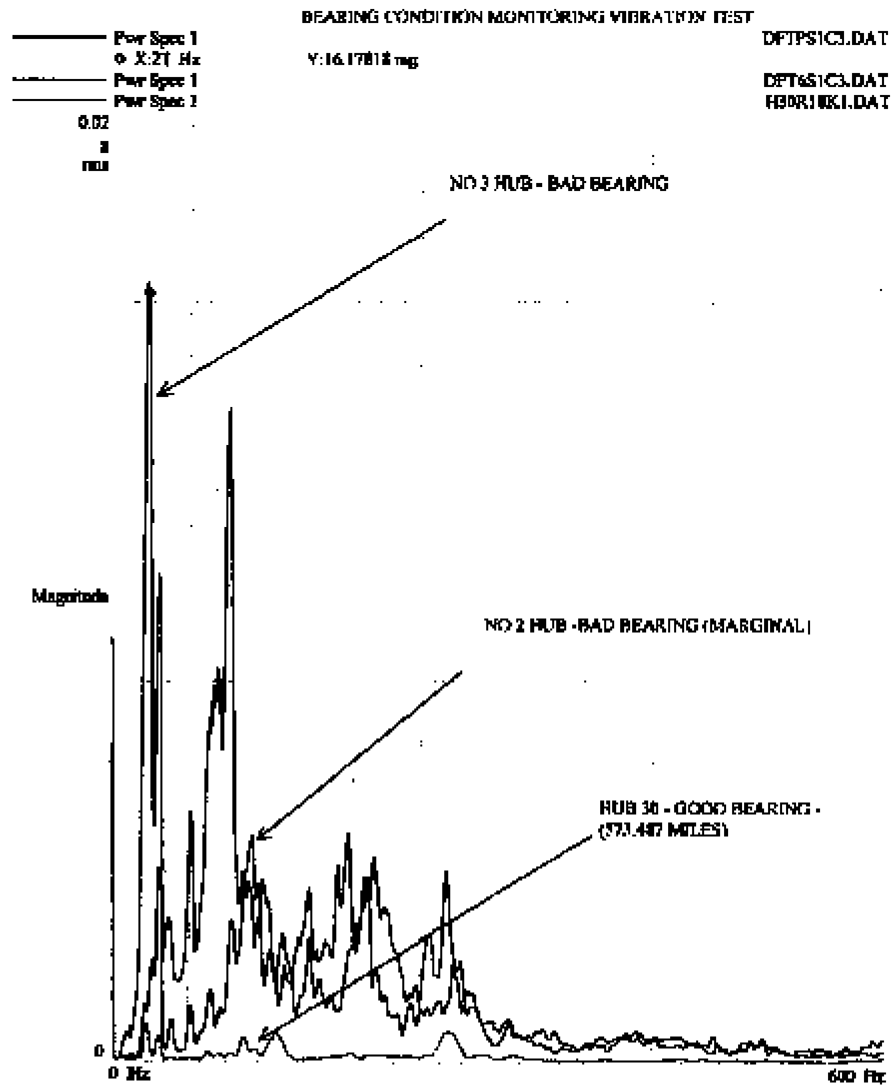
SKF

Bearing Condition Evaluation Device

- Objective: Develop a TP-0251 "Assist Device" which will give an objective, accurate evaluation of hub unit condition at PM inspections
- Performance parameters:
  - Hand rotation
  - Effective with only the weight of tire and wheel end assembly
  - Effective in the shop environment
  - Reliable/repeatable measurements
  - Rugged/industrial device
  - Simple to operate
  - Simple out-put

Vibration Characteristics

- Shows differentiation good unit vs. damaged
  - Most activity in lower frequency ranges
  - Scale of readings is small



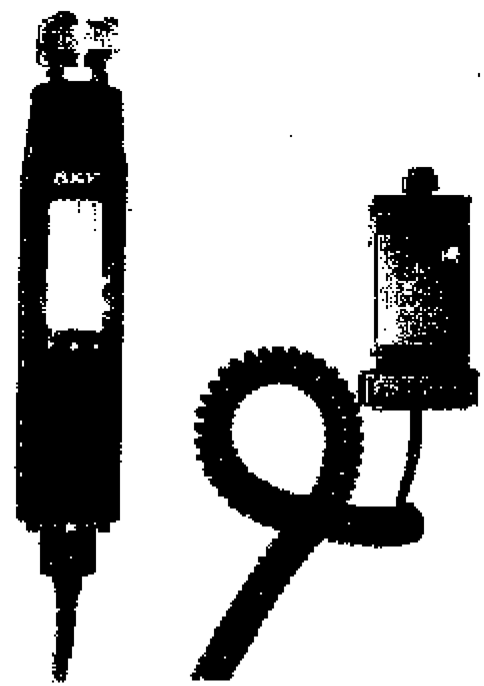
COMPARISON OF VIBRATION VIBRATION SPECTRUM AS MEASURED AT THE KINGPIN LOCATION

Prototypes Evaluated

- 3 Devices evaluated:
  - PCB
  - SKF
  - ARM

SKF Condition Evaluation Device

- Industrial unit exists
  - Used today for various industrial bearing monitoring applications
    - Used at operating speeds and loads
- Modifications required:
  - Increased gain
  - Lower electrical noise
  - Remote sampling switch and indicator lights
  - Other minor issues



Bearing Condition Evaluation Device

- The SKF Unit was chosen for production due to:
  - Degree of industrialization
  - Most easily adapted to the needs of the application
  - Shortest implementation lead time
  - Performance closely matched "Master" – HP analyzer

Inspection Process

- Raise wheel ends off the floor (on jack stands).
- Check for endplay
- Clean kingpin surface
- Mount probe on kingpin surface (magnetic probe)
- Mount assist device
- Rotate tire at 60 to 80 rpm
- Push sampling button
- Record reading (green/red)
  - Return to service or…
  - Replace hub unit

Project Milestones

- Proof of concept
  - Evaluation of all devices
- Field trial evaluation – selection
  - Ryder 7/24 & 25
- Prototype revisions
  - 7/29
  - Mechanical assist device with tachometer
- Field Evaluation – scheduled to begin week of 8/12
  - 10 Production intent units by 8/9
    - Instruction sets
    - Procedures
- Evaluation of field trial data and feedback by 8/30
- Production release 9/10

Summary Presentation

FF-981 Axle

01 August 2002

ArvinMeritor

SKF

SKF 001481

Agenda:

- Meeting Purpose
- Summary
- Product / Market History
- Product Performance History
- Root Cause Investigation
- Corrective Actions
- Recommended Action Plan

Meeting Purpose

- Review Field Performance of the FF-981 Product
- Review Corrective Actions to Improve Product Performance
- Recommend a Course of Action For the Field Population

Summary

- In Aggregate the Field Performance of the FF-981 Has Been Excellent
- Recent Spikes of Warranty Claims at a 1 to 2 % Rate Have Been Observed In The Production Period 1999 Through 2002
- Root Causes Have Been Identified
- Final Solutions For Identified Issues Have Been In Place Since April 2002
- Further Investigation / Inspection Is Required
- Bearing Degradation Is Detectable During PM and Imminent Failure Is Apparent to the Vehicle Operator

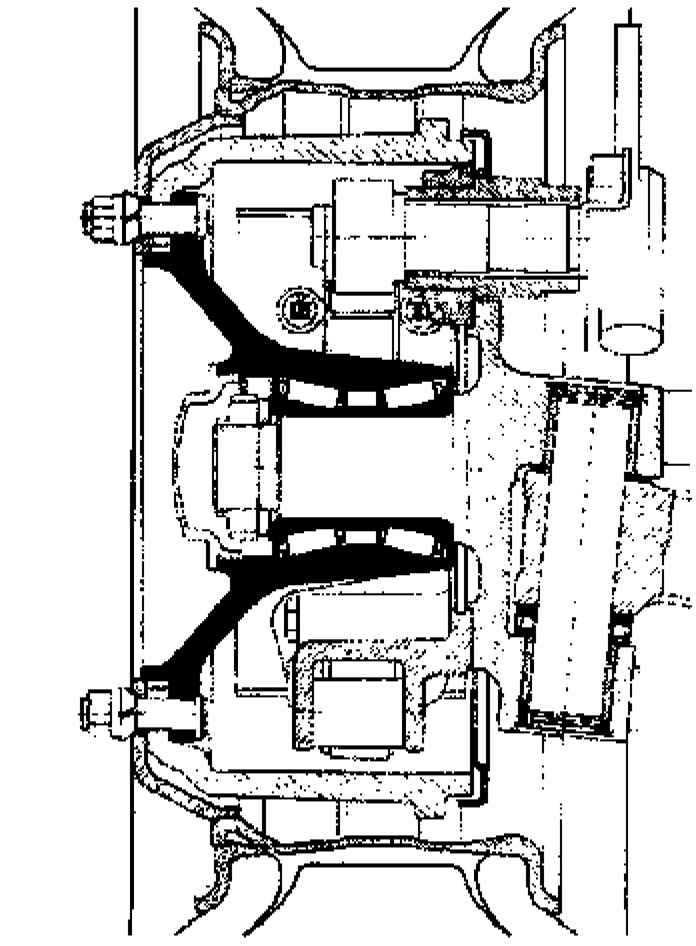
FF-981 Hub Production

Year	Total	Freightliner
1996	7486	6376
1997	34416	24614
1998	76036	43152
1999	112098	65812
2000	85690	45804
2001	35838	18988
2002 est	36000	18000

Steer Axle System

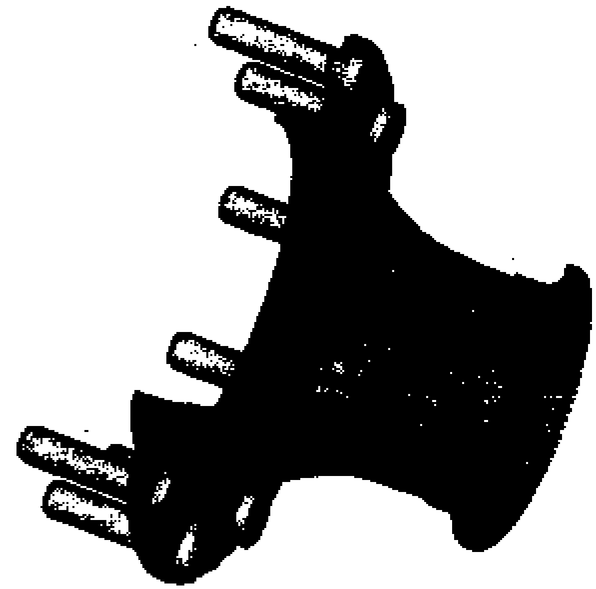
Consists of:

- Fully Integrated System
- Sealed Bearings
- Low Maintenance



Hub Sub-System

Consists of:



- **Bearing Geometry**
- **Sealing**
- **Long Life Grease**
- **Environmentally Controlled Assembly**

Front Steer European Customers:

- Iveco
- RVI
- Man
- Scania

- 1.3 million Steer hub units since 1995
- RVI has Same Grease and Seal as the early FF-981 Unit

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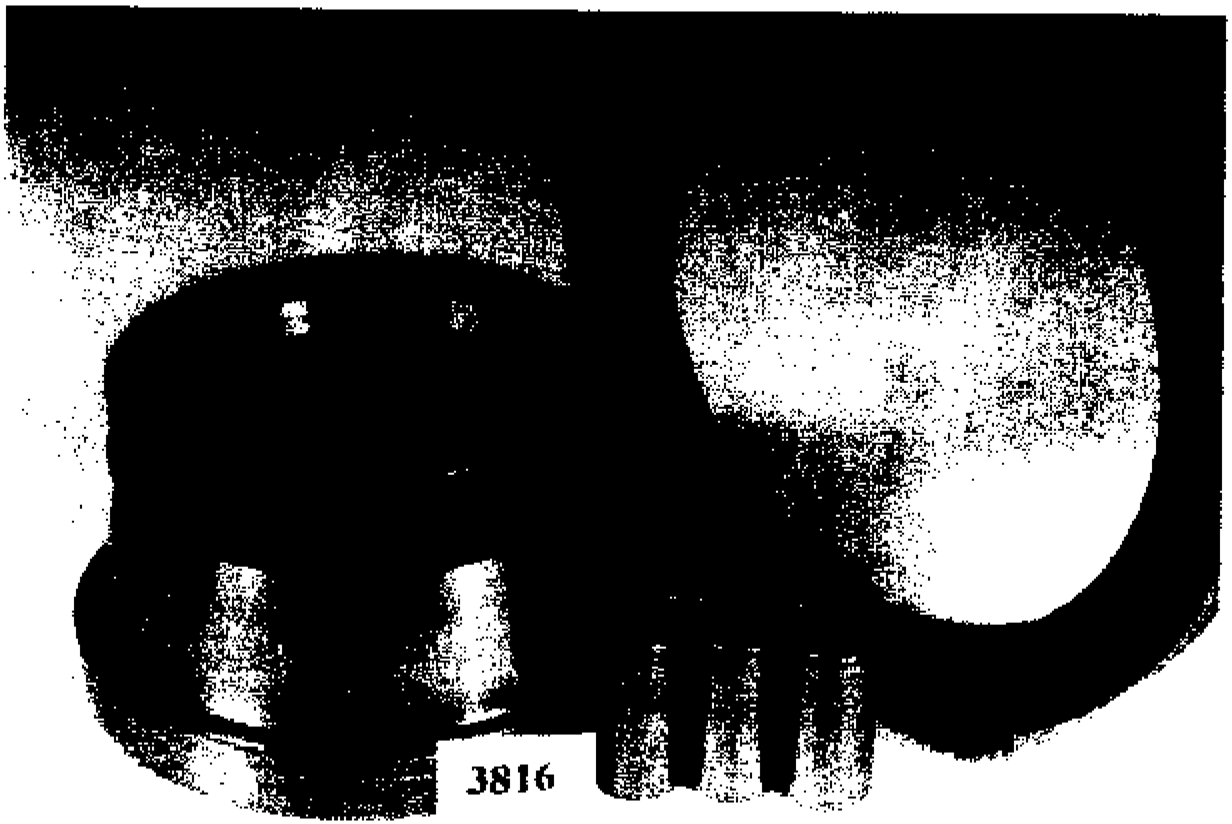
Performance



SKF 001490

After 876,000 Miles – Like New

August 1, 2002

SKF

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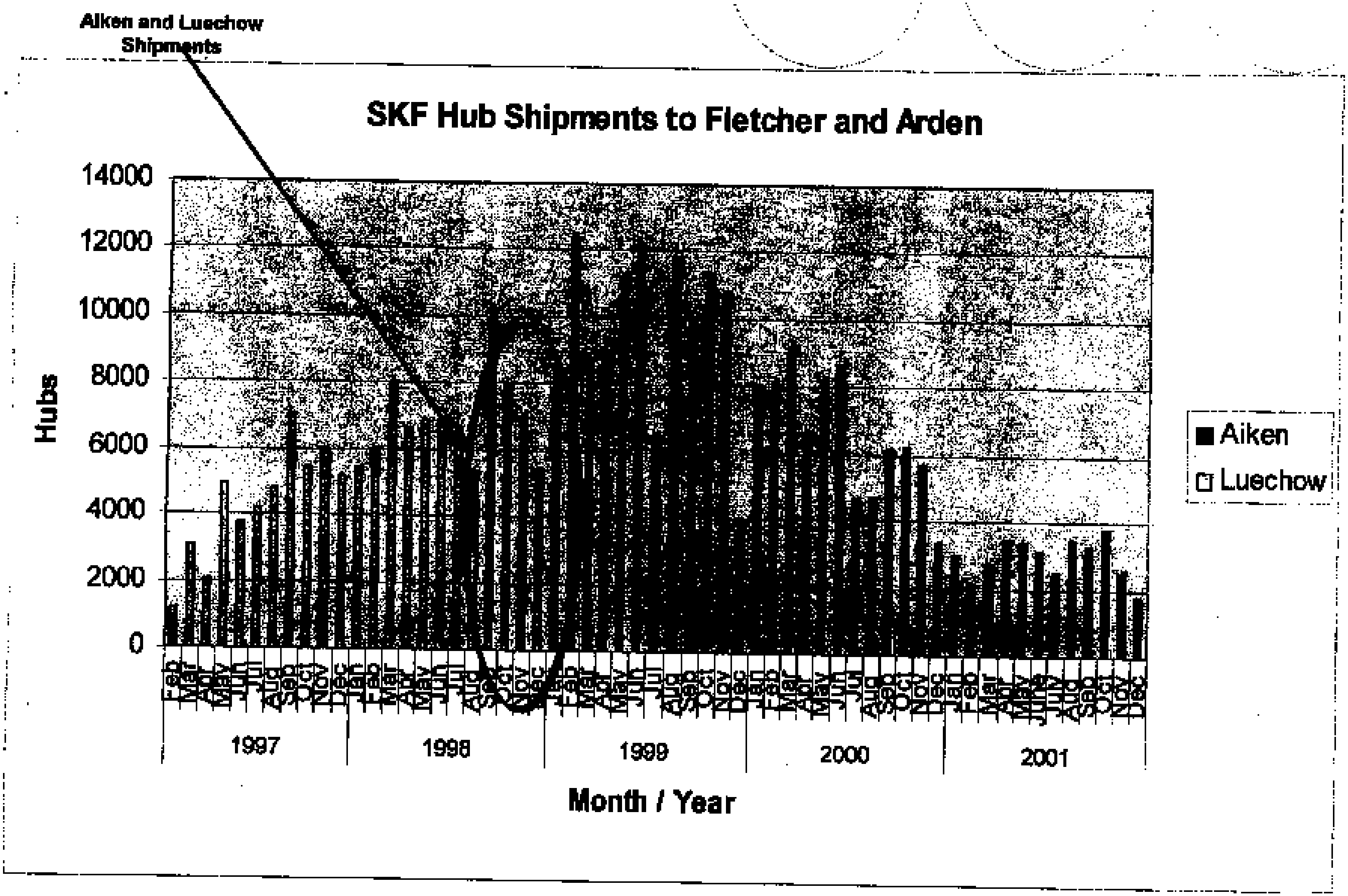
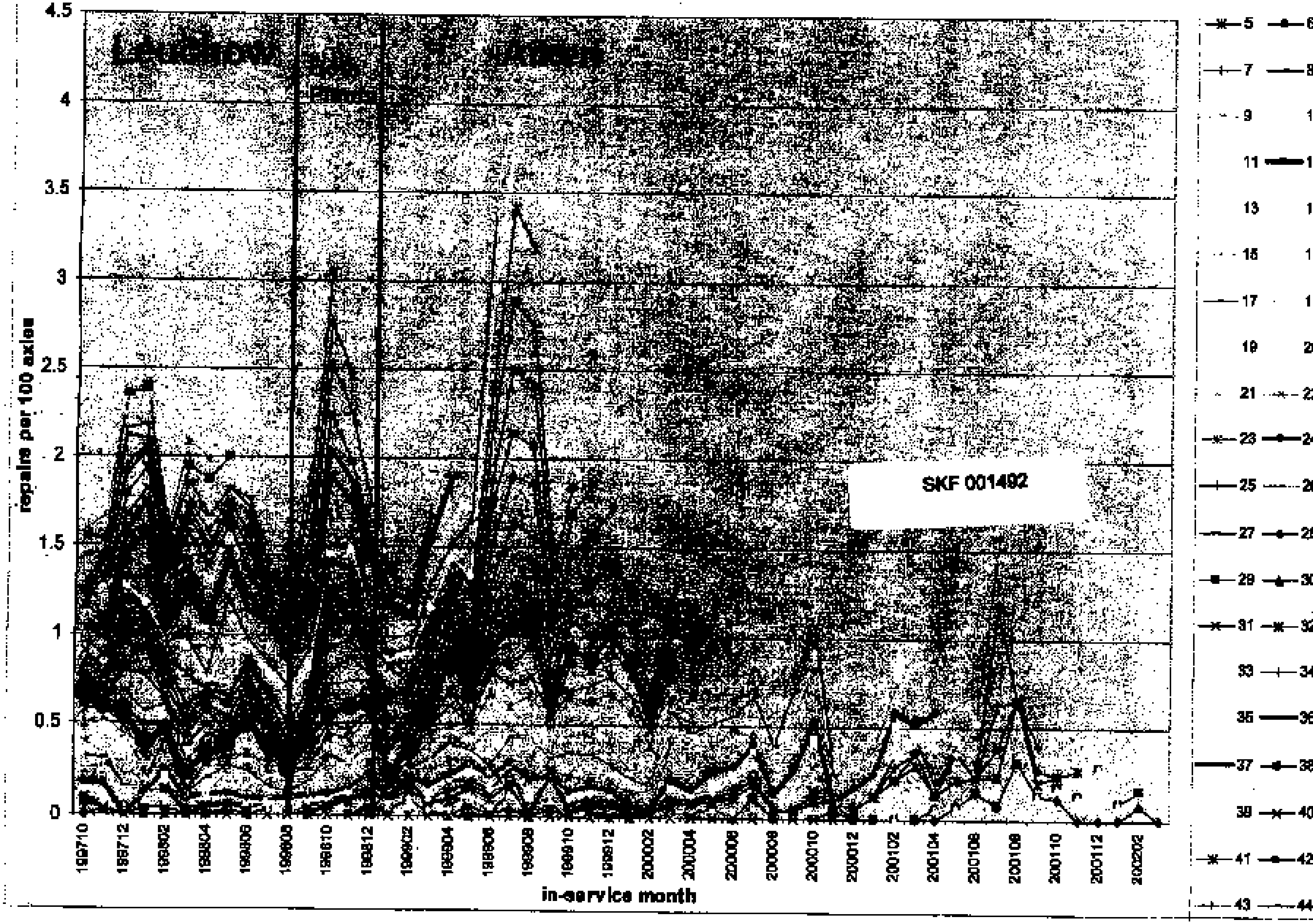
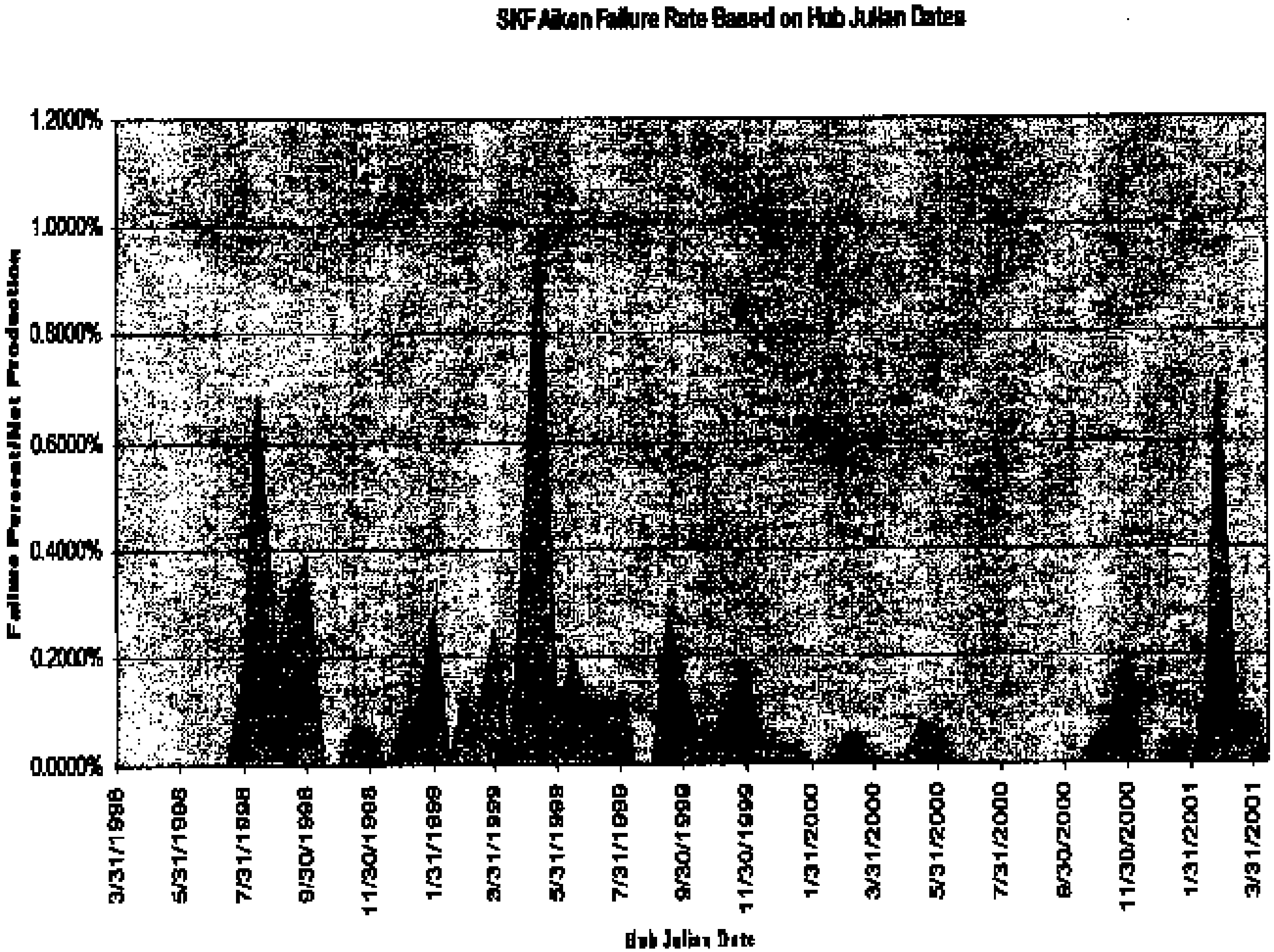


FF98X Hub Warranty Performance - Claims Thru June 2002



SKF 001492

Aiken Data



375 Hubs

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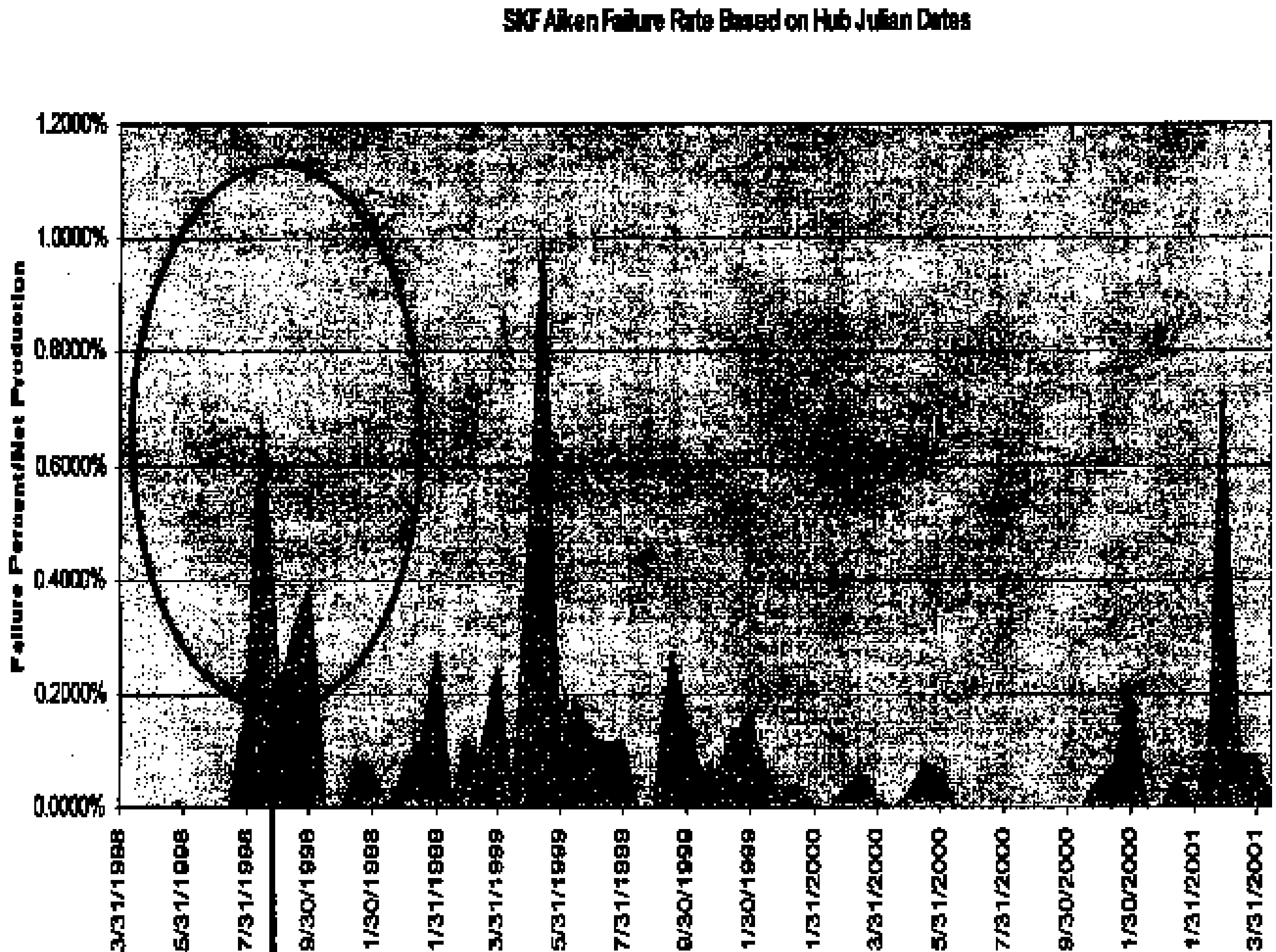
Aiken Launch



- Contamination
- Problematic Launch
- Hub Thread and Cap Deviations

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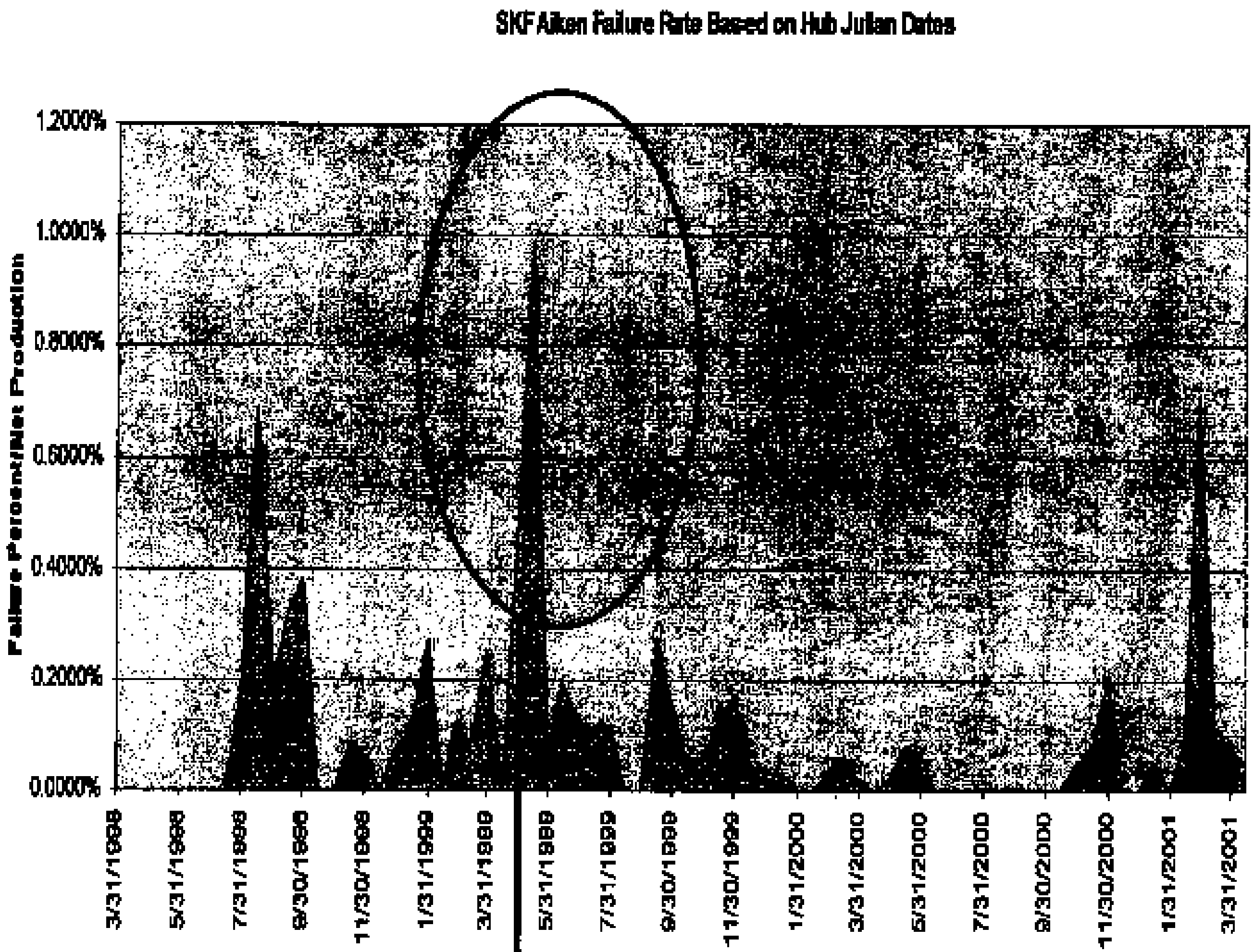
Three Issues



- Contamination
- Axial Clearance Issues
- Hub Thread and Cap Deviations:

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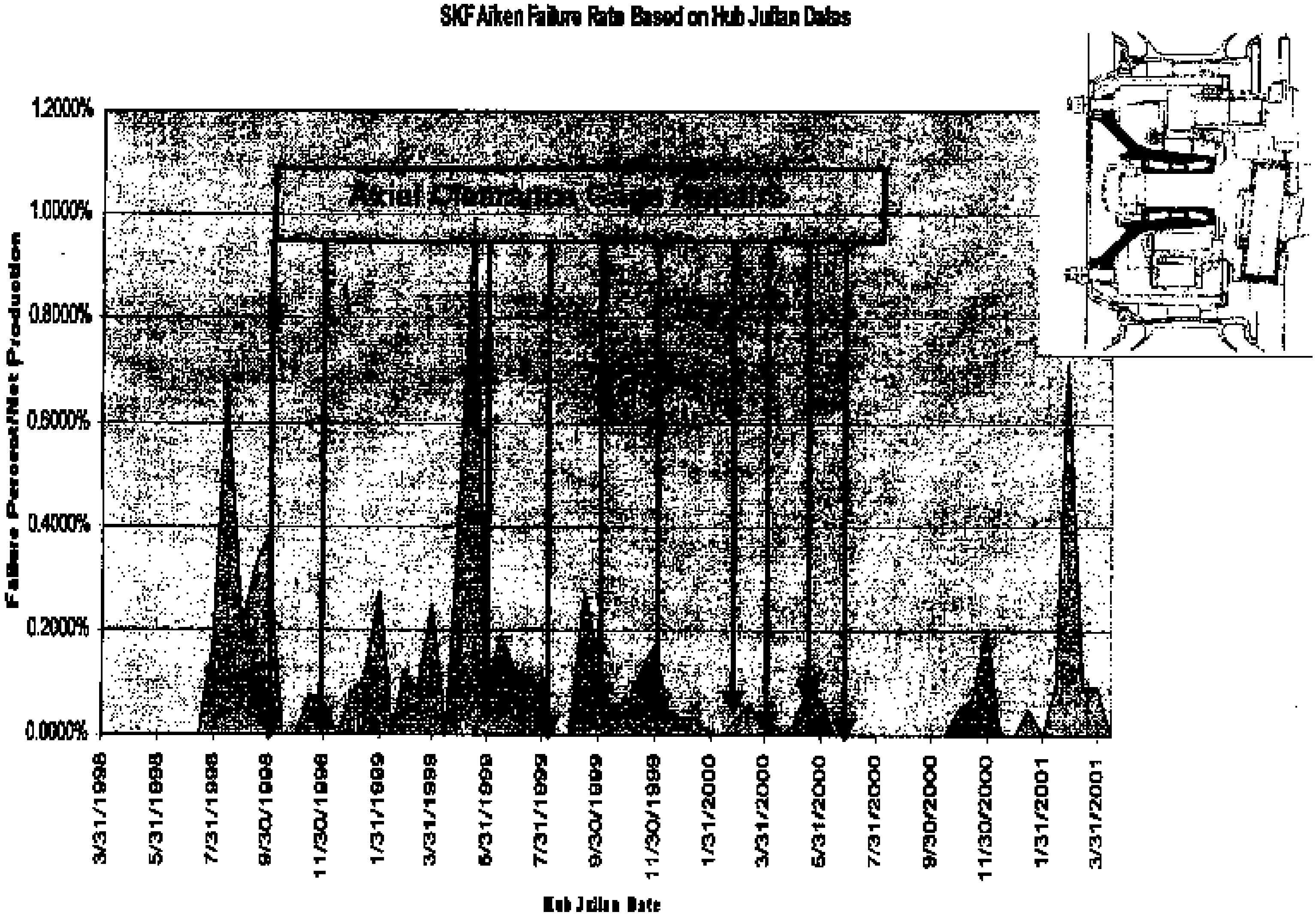
Axial Clearance



Aug

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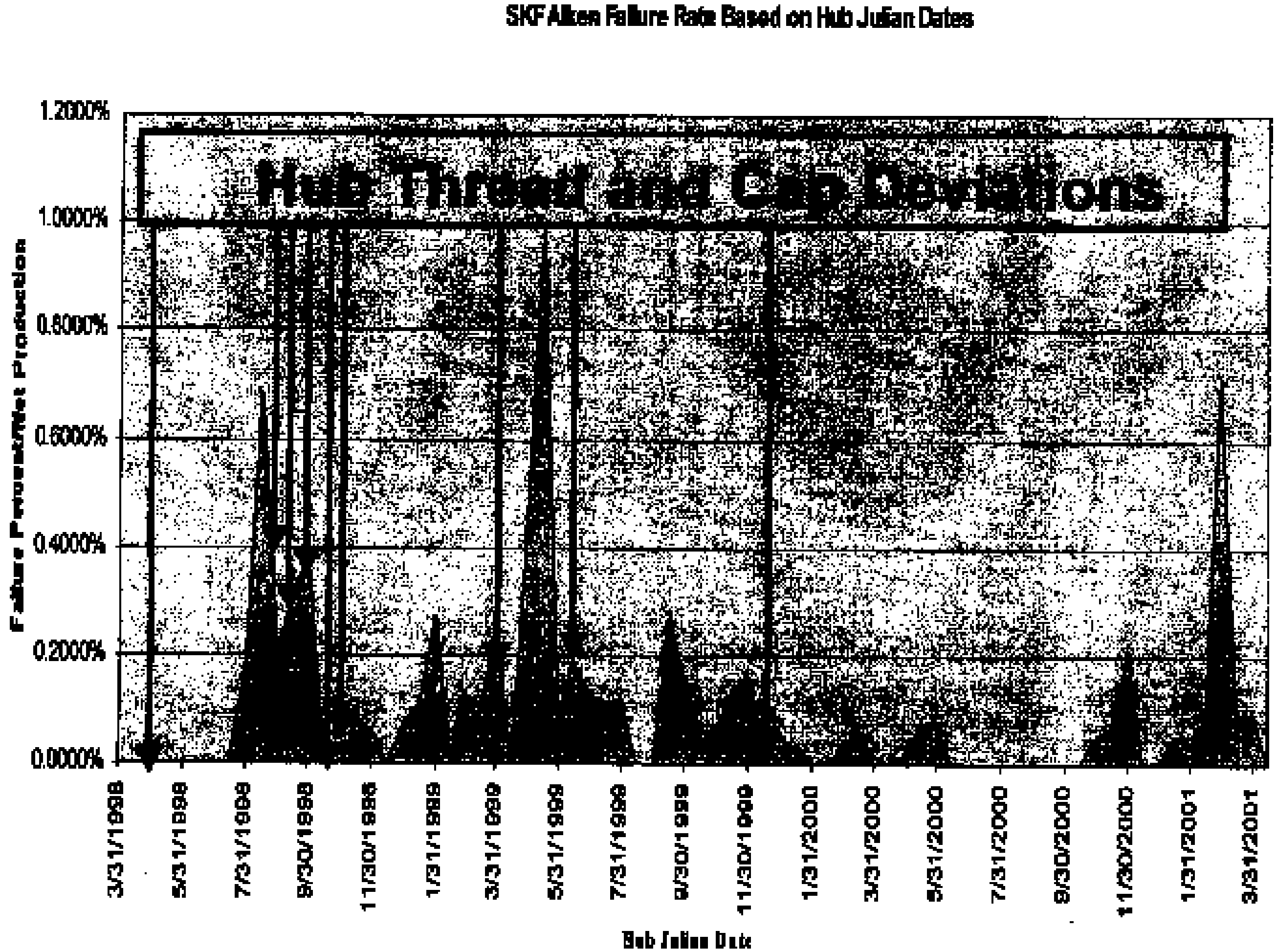
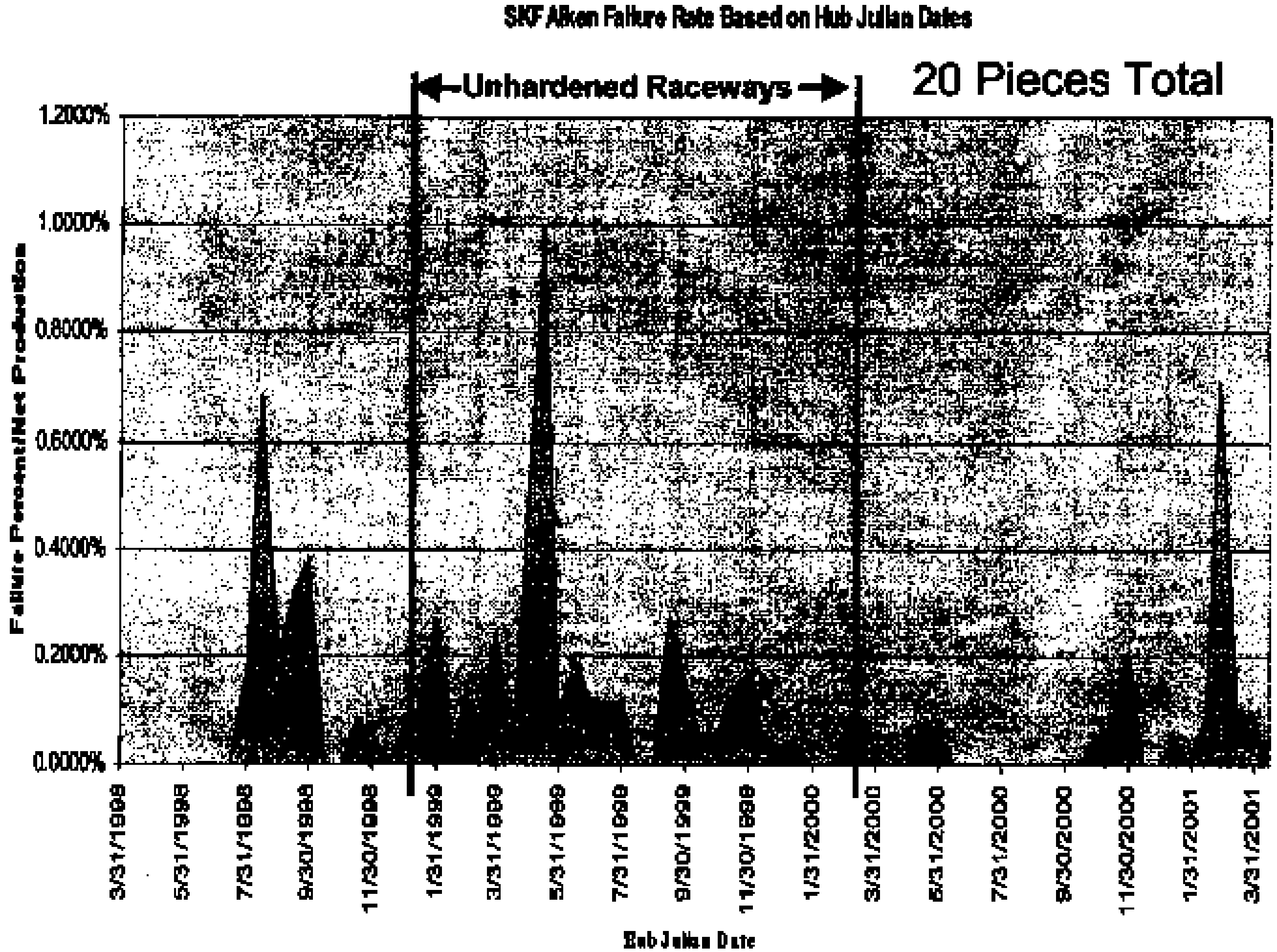
Hub Cap & Threads



Unhardened Raceways



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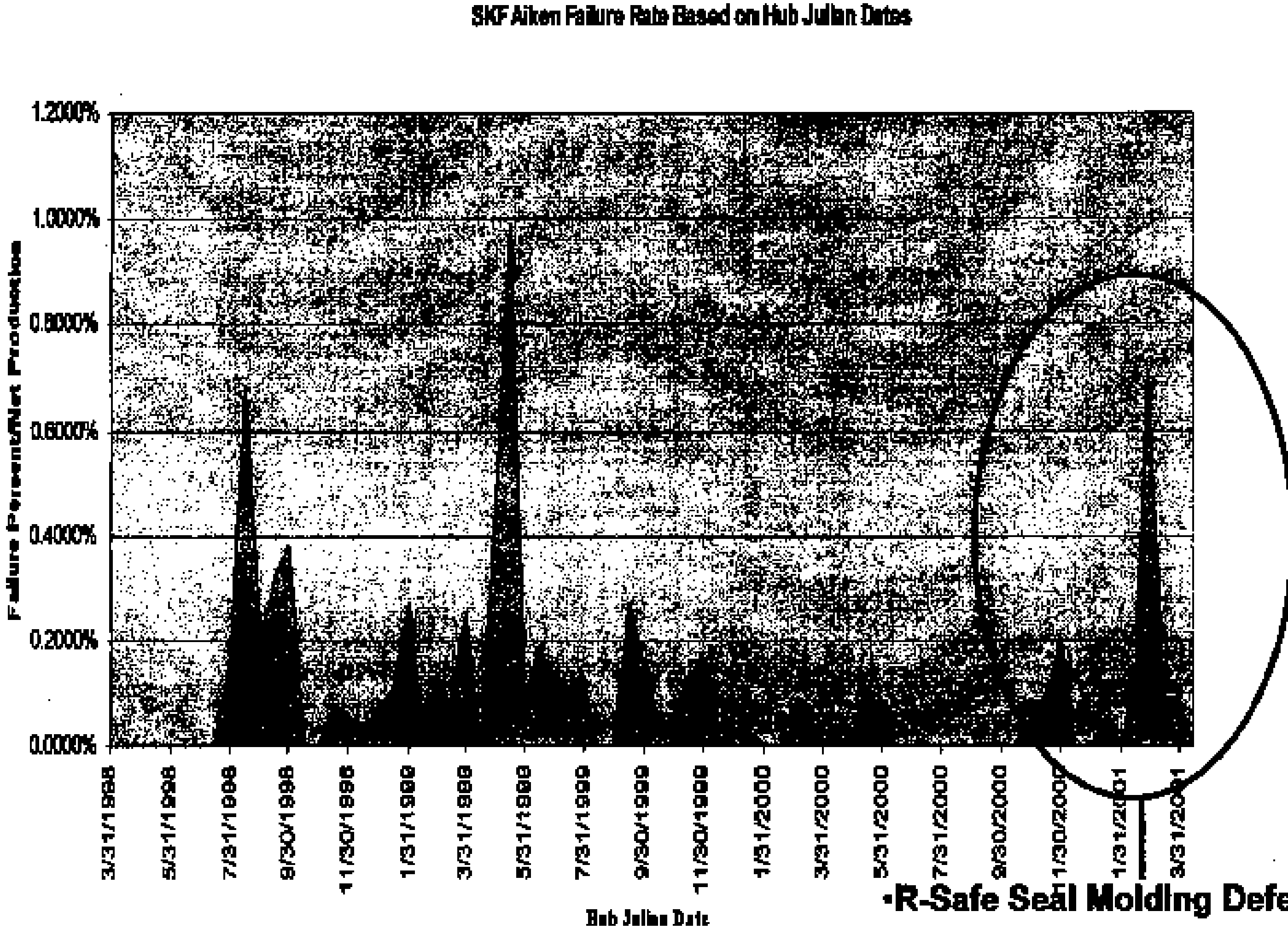
R-Safe Seal



- **R-Safe Seal Molding Defects**
- **60,000 hubs Produced**
- **Self Healing Property**

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Product and Process Enhancements:

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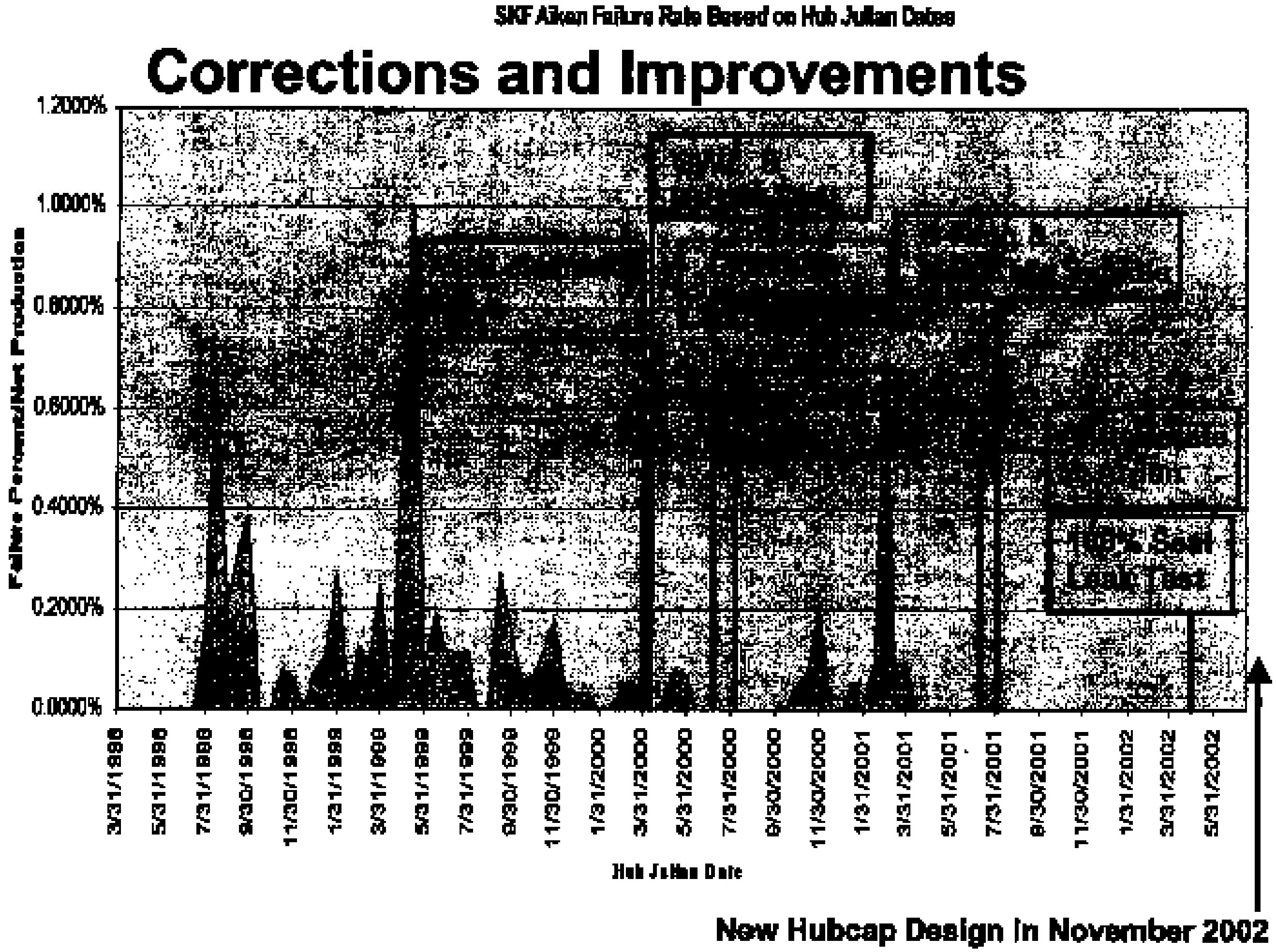

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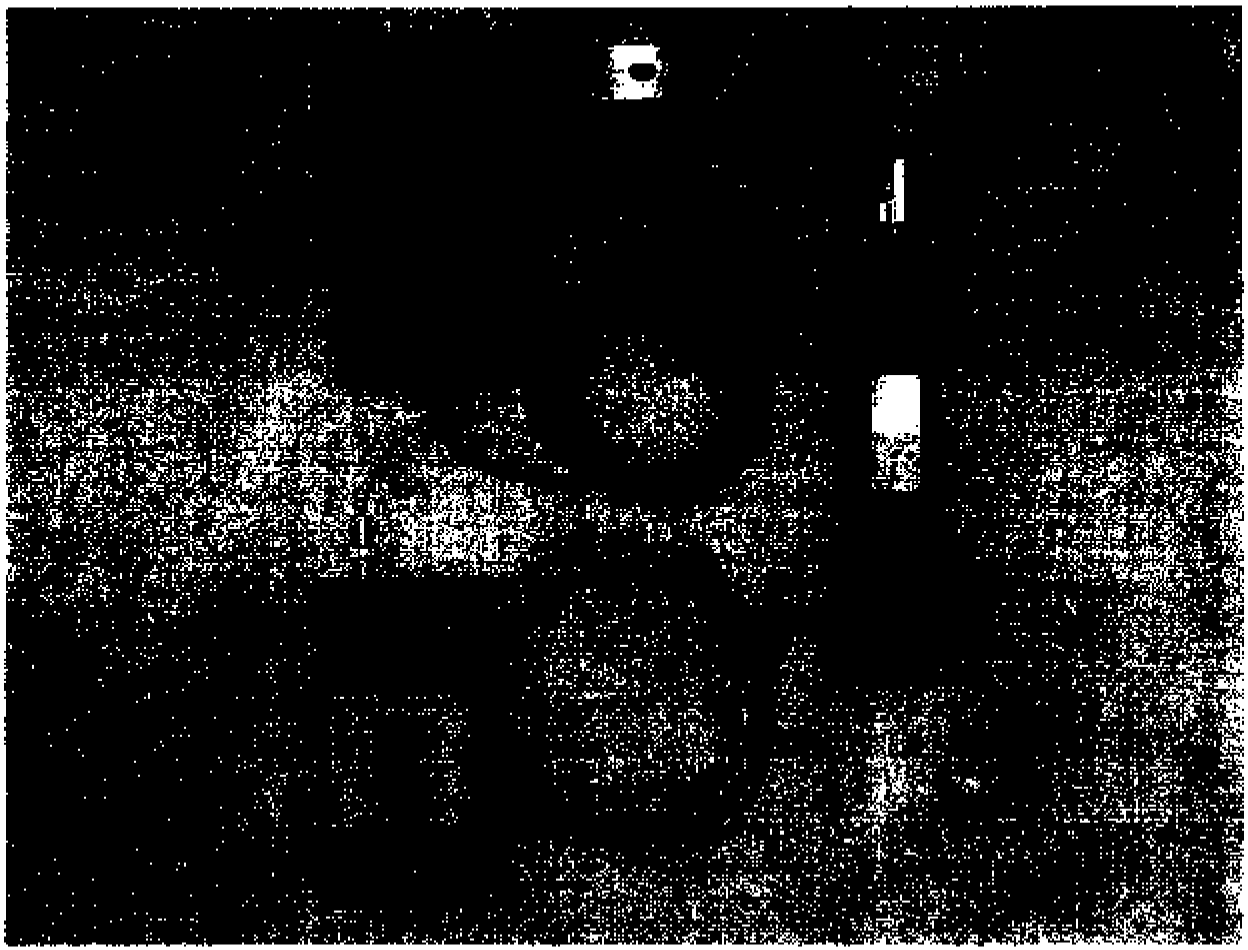
Vibration Monitoring



[illegible] Condition Evaluation Device

August 1, 2002
Freightliner

ArvinMeritor

SKF

SKF 001507

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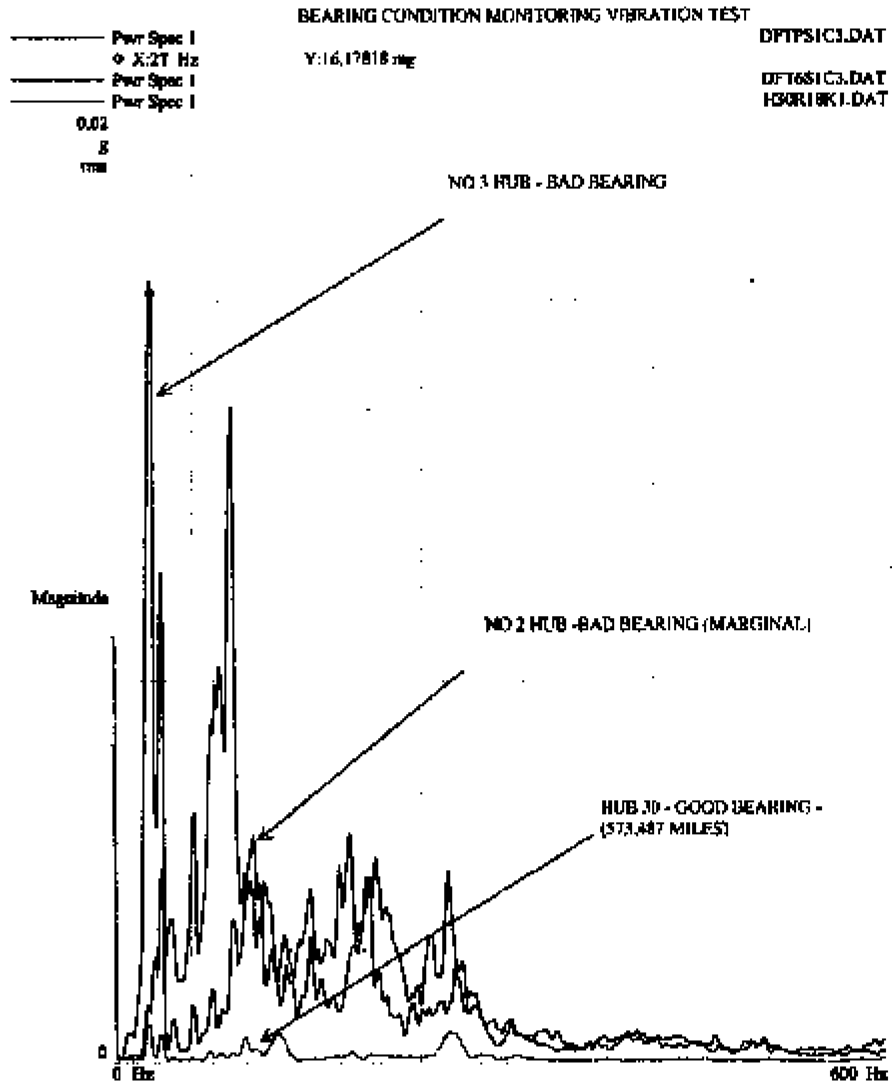

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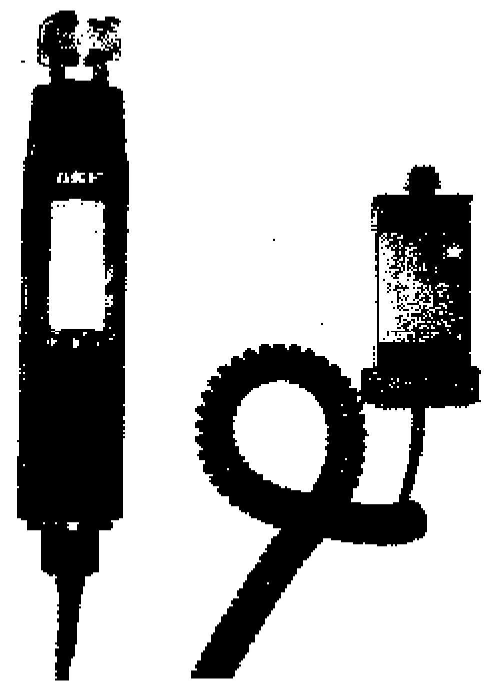

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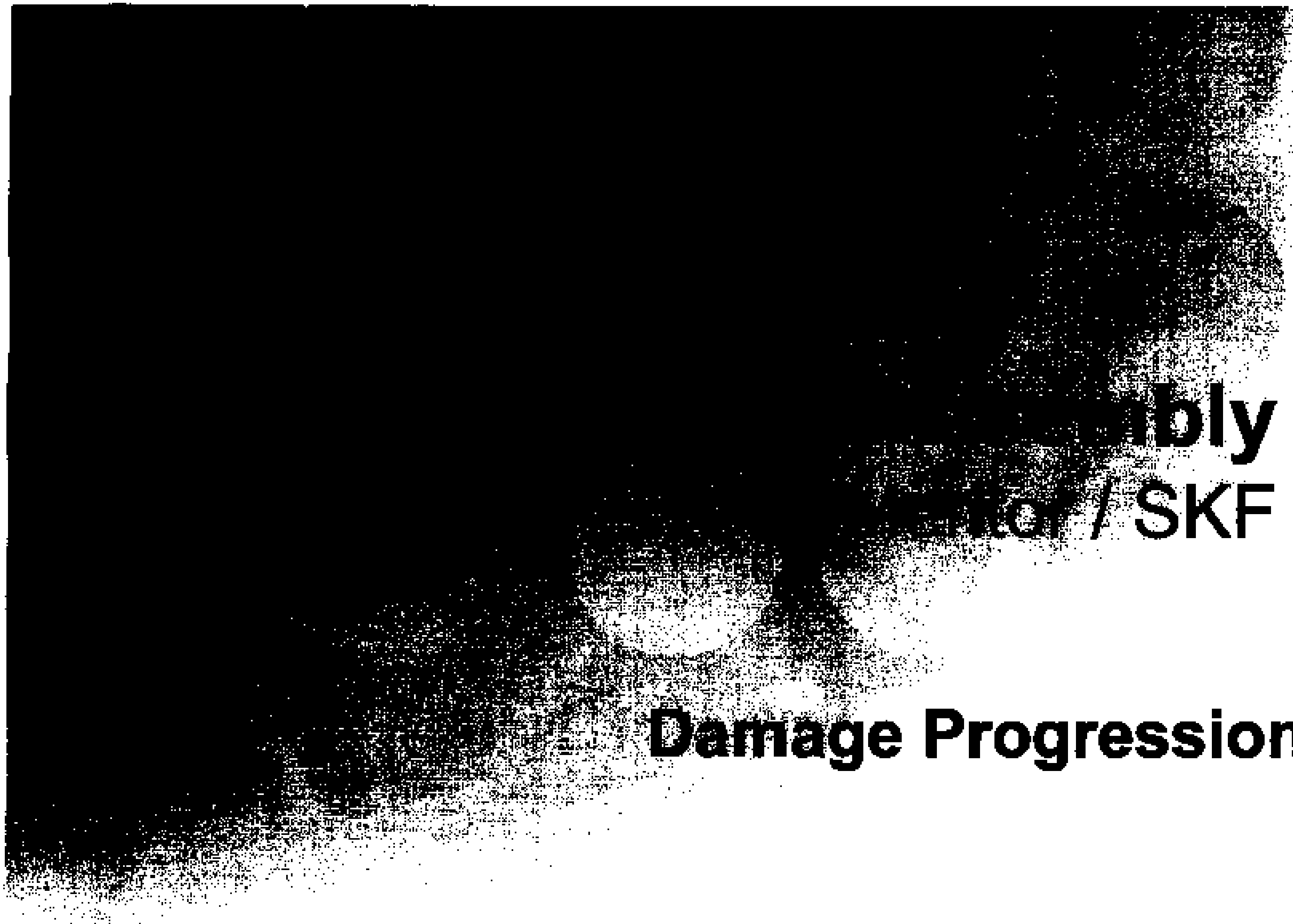

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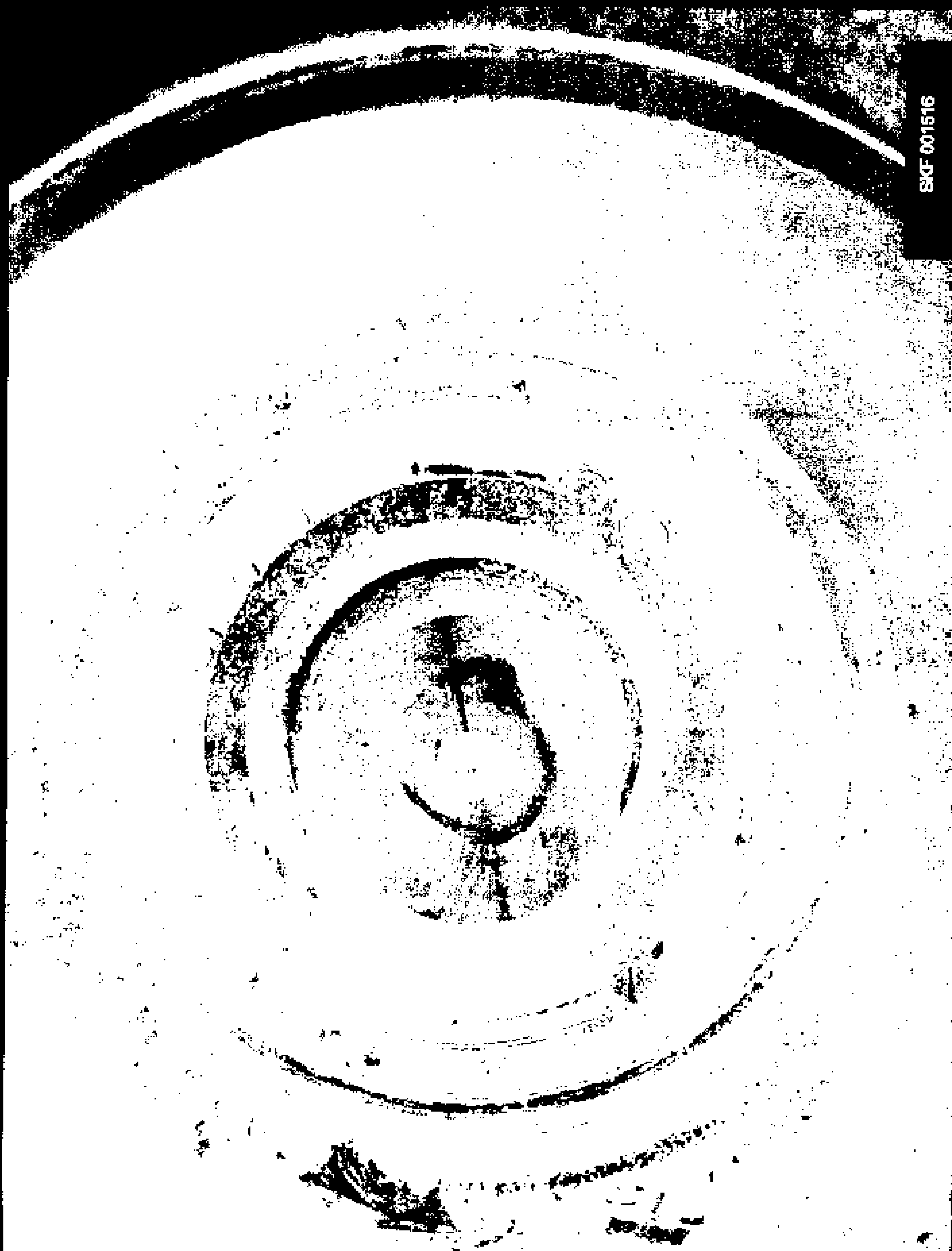
Damage Progression

ArvinMeritor

SKF 001515



SKF 001516

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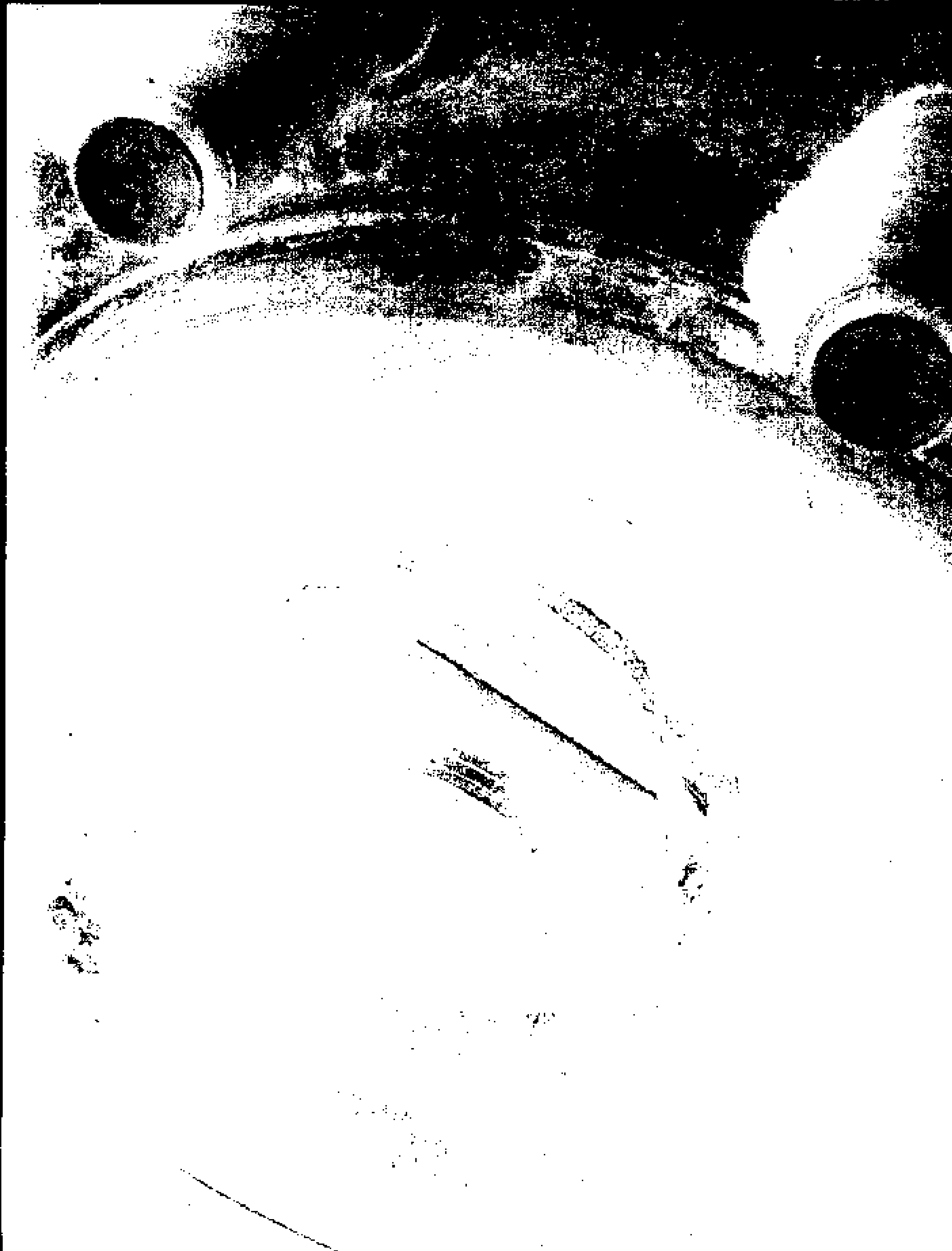
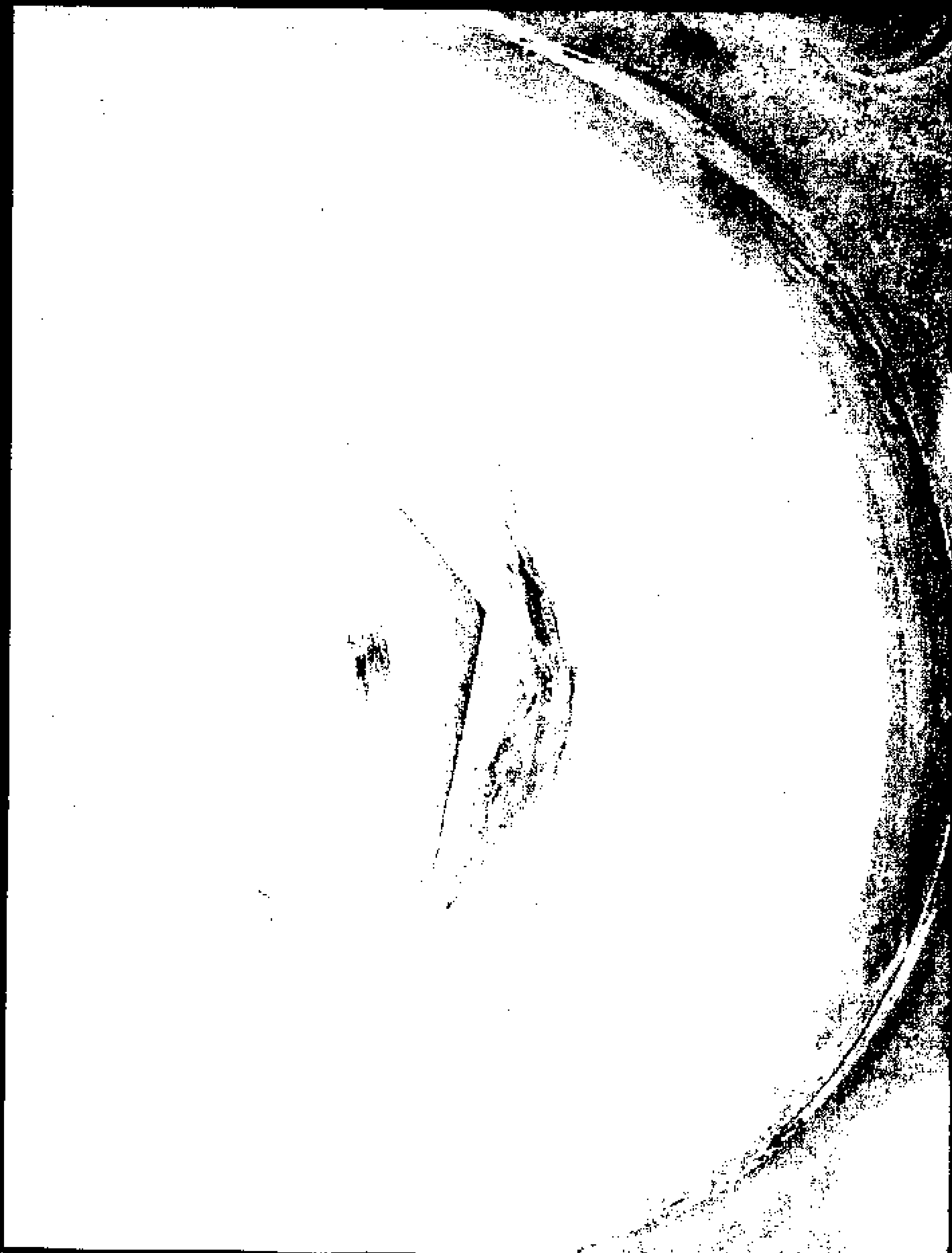
SKF 001516





SKF 001519

SKF 001520

SKF 001521

SKF 001522

SKF 001523

- FMEA 'detection' validation
  - Builds off past work (June 2001)
    - What was done:
      - » Bearings run to spall initiation in lab
      - » Brake linings, tire bead, spindle, drag link instrumented
      - » Accelerometer mounted to steering wheel, knuckle
      - » Distance & speed recorded
      - » 'Damaged' hub put on LH end, properly assembled

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- FMEA 'detection' validation (cont.)
  - Builds off past work (June 2001) (cont.)
    - – Results:
      - » 2 hrs, 60 mph - no effect measured
      - » Removed every other roller
      - » 2.5 hrs @ 55-60 mph - no effect measured
      - » 'Gentle swerving' introduced - 5 minutes, spindle temperatures reached 325°F
      - » Next day: 'gentle swerving' continued
        - + ABS fault noted
        - + 1/2 hour - spindle temperature @ 300°F, burning odor, intermittent grinding noise, loud 'bangs' with steering wheel and cab floor response: obvious mechanical failure

SKF 001525

- FMEA 'detection' validation (cont.)
  - Builds off past work (June 2001) (cont.)
    - Results:
      - » Next day
        - + ½ hour - spindle temp 375°F, steering feels 'sloppy,' non-responsive, no pulling
        - + ½ hour - spindle temp 375°F, strong jolt on steering wheel, 'pop', 'bangs'. Wheel shutters when turning right
        - + ½ hour - spindle temp 375°F, chatter and steering wheel vibrations when turning right, 'pop' and grinding continues. Brake and tire tread temperatures are still near ambient.
        - + 5 minutes: rollers eject from hub, feels like flat tire
        - + Continue at 40 mph: cab shakes, hard pull left: after 3 miles, brake shoes at 1100°F, at 6 miles, 1500°F and rising
        - + Stop, fire is extinguished
        - + Similar results for RH hub test

- FMEA 'detection' validation (cont.)
  - Builds off past work (June 2001) (cont.)
    - Conclusions: Failure is detectable
- Recent Test:
  - Near-off hub reinstalled: run @ 20mph
    - Some noise, smell, hard pull
  - Bosch Proving Ground Test
    - Bearing spall has been initiated
    - Packed with used grease & seals installed
    - Instrumented: no 'gentle swerve'
    - Status
    - Problem detected per TP-0251 @ 10,270 miles
    - Vehicle test miles: 58,185
  - SKF Vehicle Test
    - Hubs selected via TP-0251 from field samples
    - Test launched at Southwest Research
      - » RH Hub: Potential post 7/2000 seal issue; detection @ test start
      - » LH Hub: Pre-7/2000 sample; detection @ 4,199 miles
      - » Test continues @ 23,476

Discussion

[illegible]
Ju[illegible]
Schult[illegible]
08/02 10:3[illegible]

Subject: Capability studies: internal geomtry IR

Category: Quality

Capability studies were carried out to show that opertions with dressing rollers are capable and robust.
Sampling routine was like following:

10 samples at the beginning of the shift
10 samples at the end of the shift
each hour in between 5 samples

cap_IR_ribangle.12: cap_IR_racewaycrowning.12 cap_IR_racewayroundness.1: cap_IR_racewayangle.12

SKF 001528

Discussion

Ma...

Schil...

08/.. 03:0...

Subject: Internal Geometry - Luechow Production 98

Category: Quality

Attached summary of internal geomtry figures from Luechow - production 1998:

InternalGeom_Luechowprod98.

SKF 001634

Discussion
Main Topic

Robert J Bondy/DET/SKF
07/29 10:16 PM

Subject: Revised Freightliner Presentation as of 10:13 pm montag

Category: Information

Ftl072902.ppt This is a big file - Detach before opening

Presentation Title

Subtitle

Presentation Date
Presentation Venue

SKF 001537

ArvinMeritor

Agenda:

- Basic Information
- FF-981 Features
- Volume Information
- Warranty History
- Causes and Corrective Actions
- Detection
- Recomendations

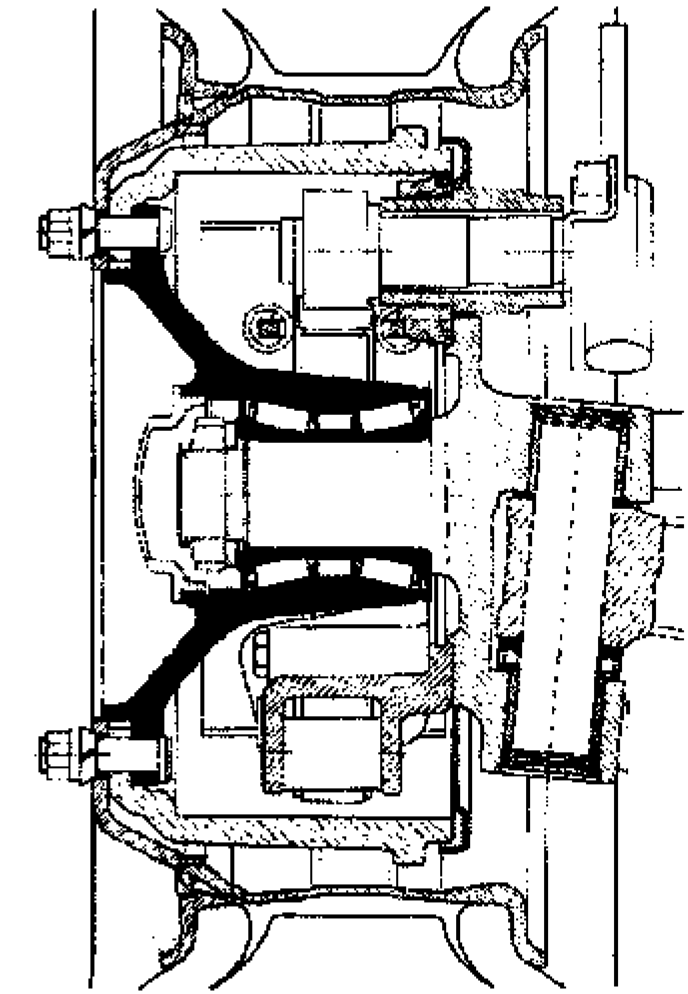
SKF 001538

ArvinMeritor

Steer Axle System

Consists of:

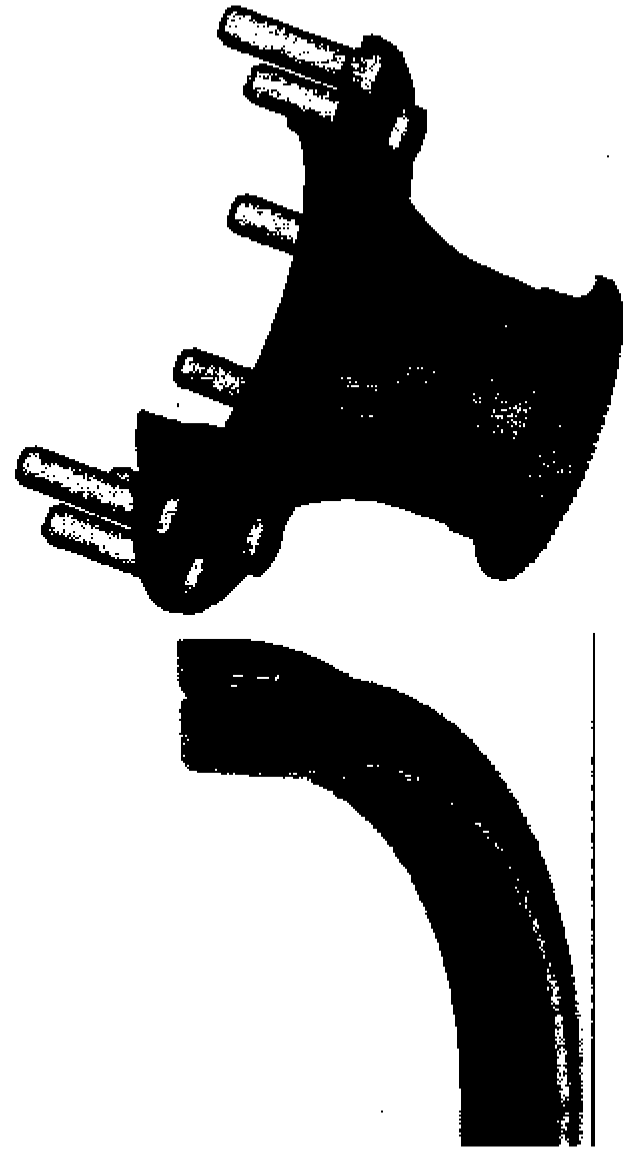
- Axle
- Bearing System
- Knuckle
- Spindle
- Mounting Hardware
- Hub Cap



Bearing System

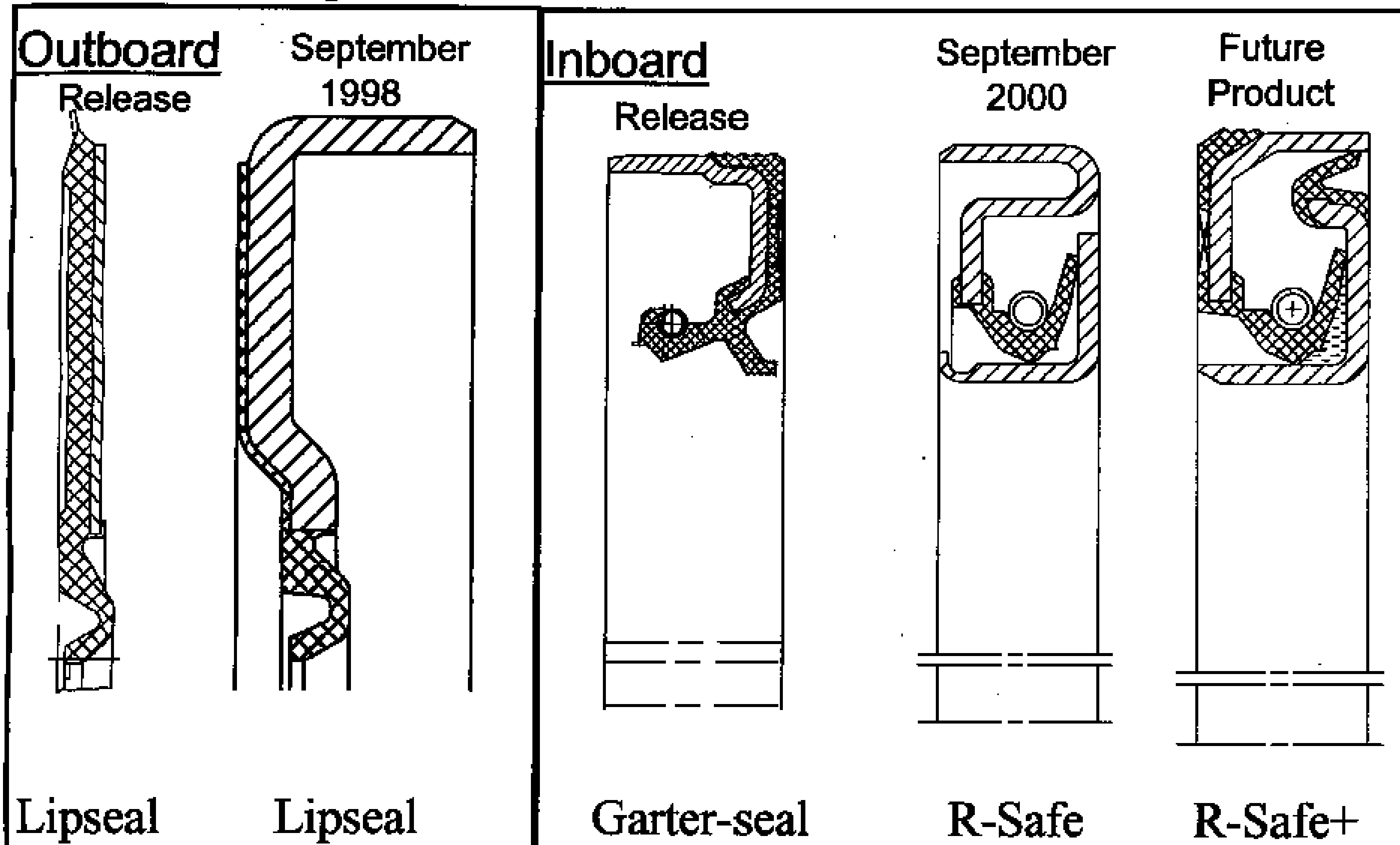
Consists of:

- Bearing Geometry
- Sealing
- Long life Grease
- Environmentally Controlled Assembly

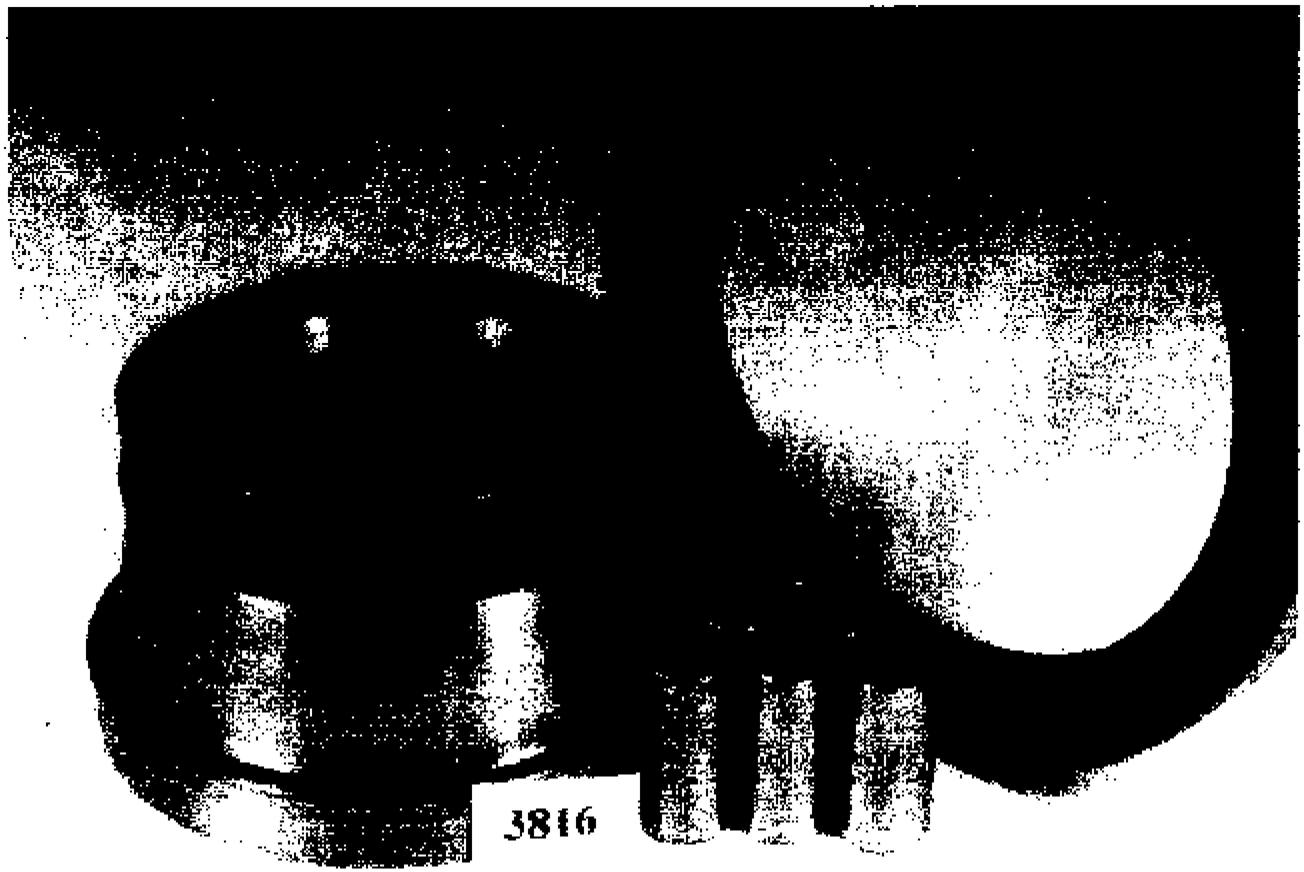


ArvinMeritor

Seal Designs



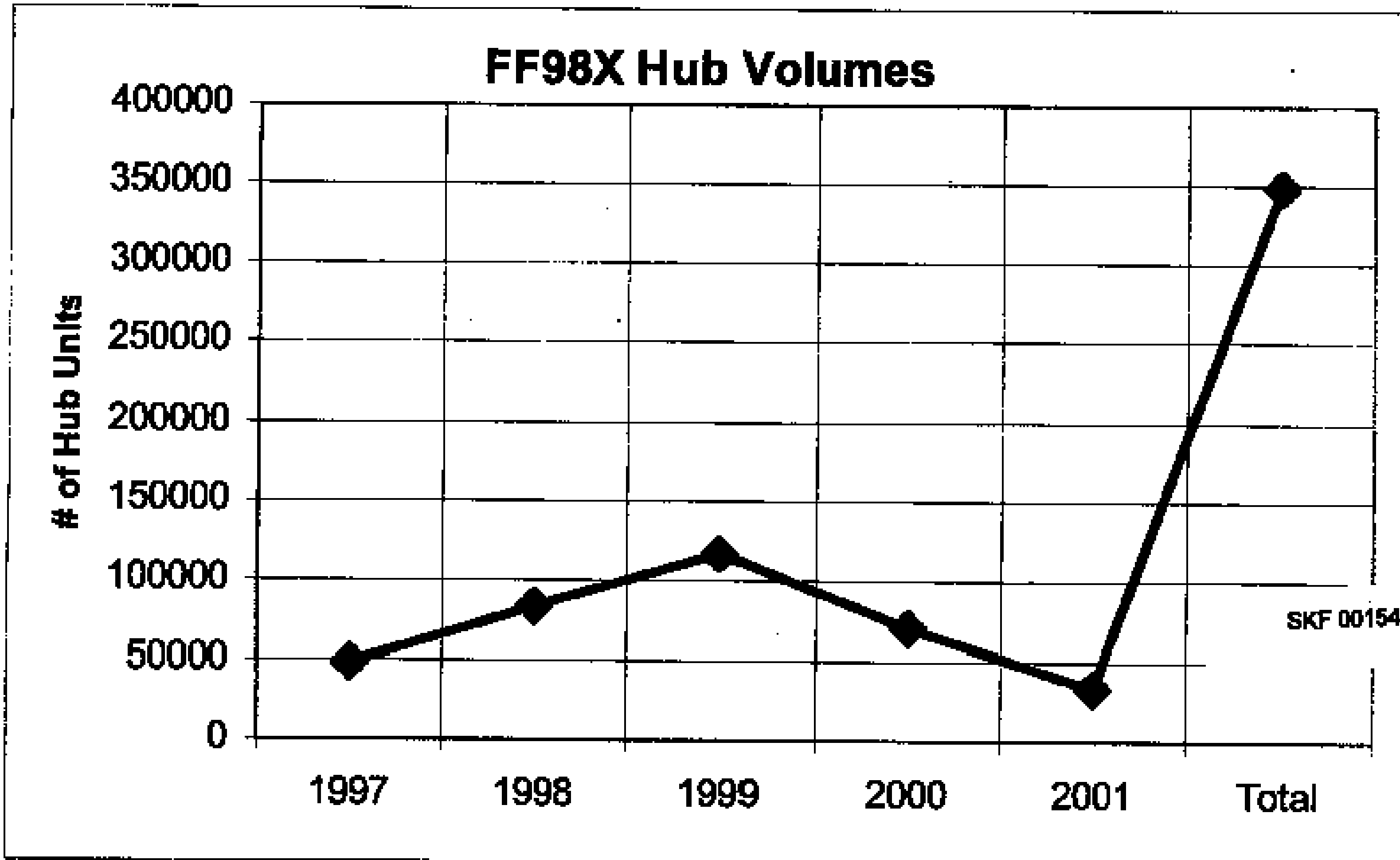
Expectations of the Steer System



SKF 001644

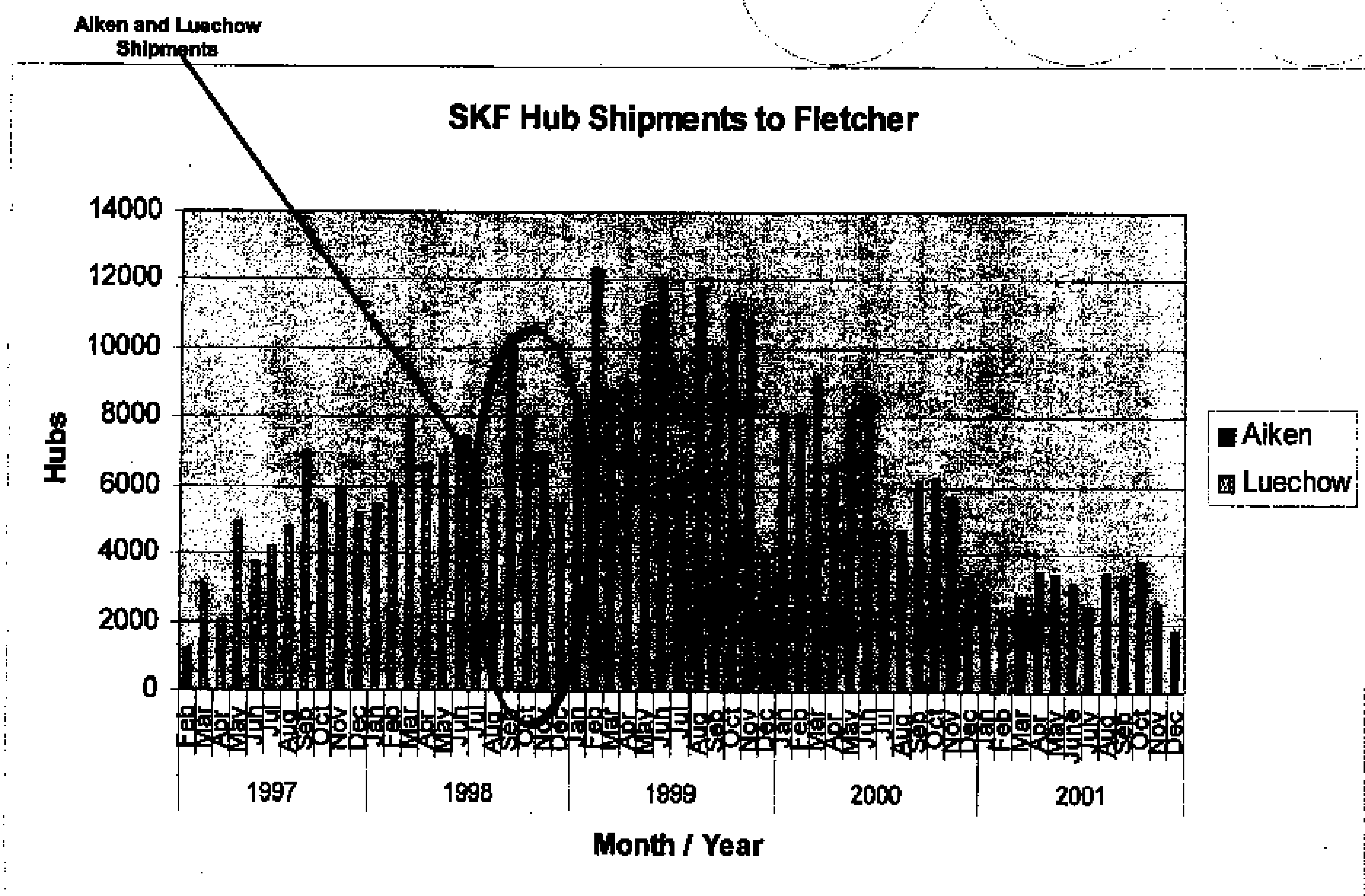
After 876,000 Miles – Like New

- The Data
  - Hub population (through Sept '01)

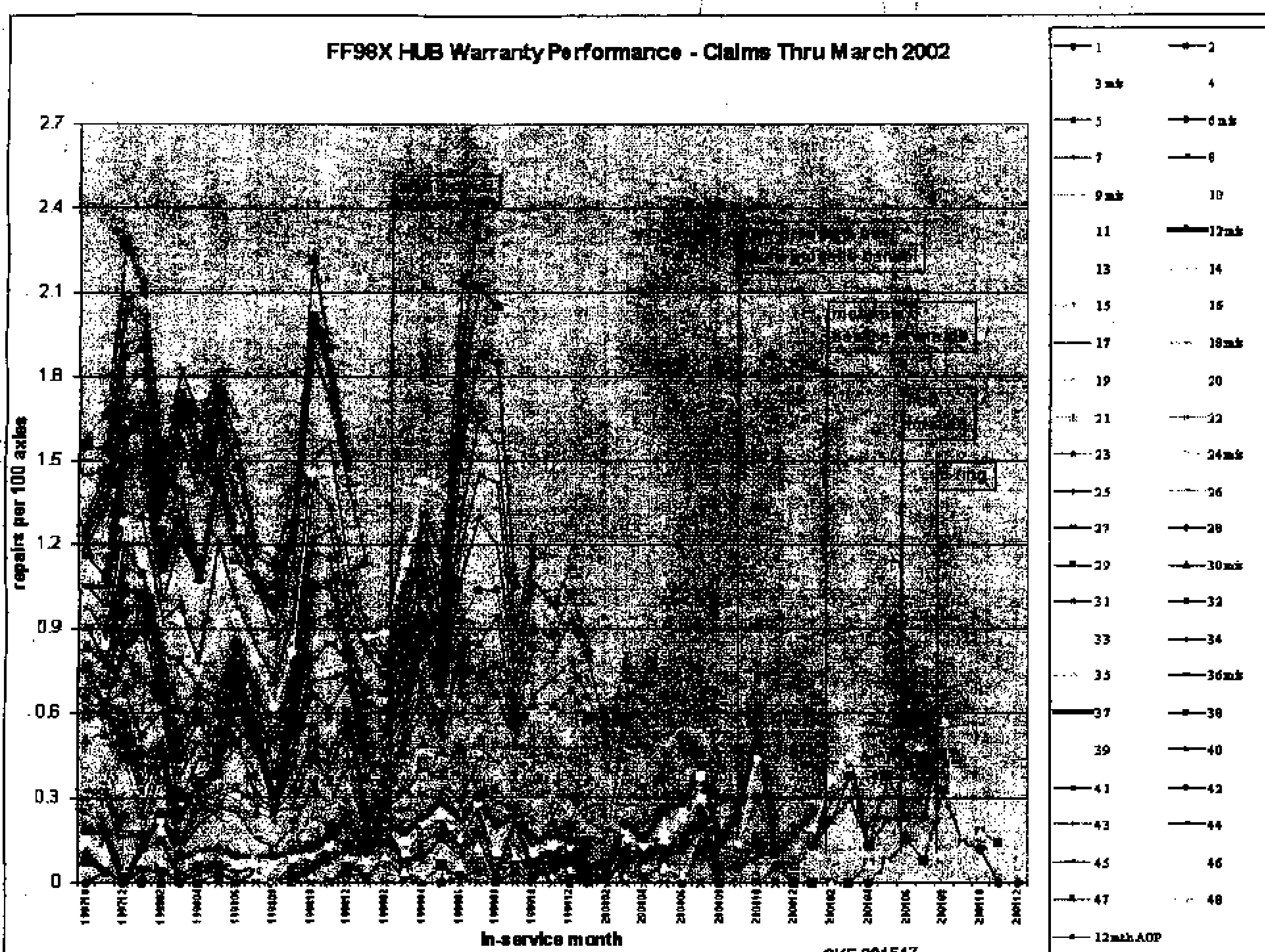


SKF 001545

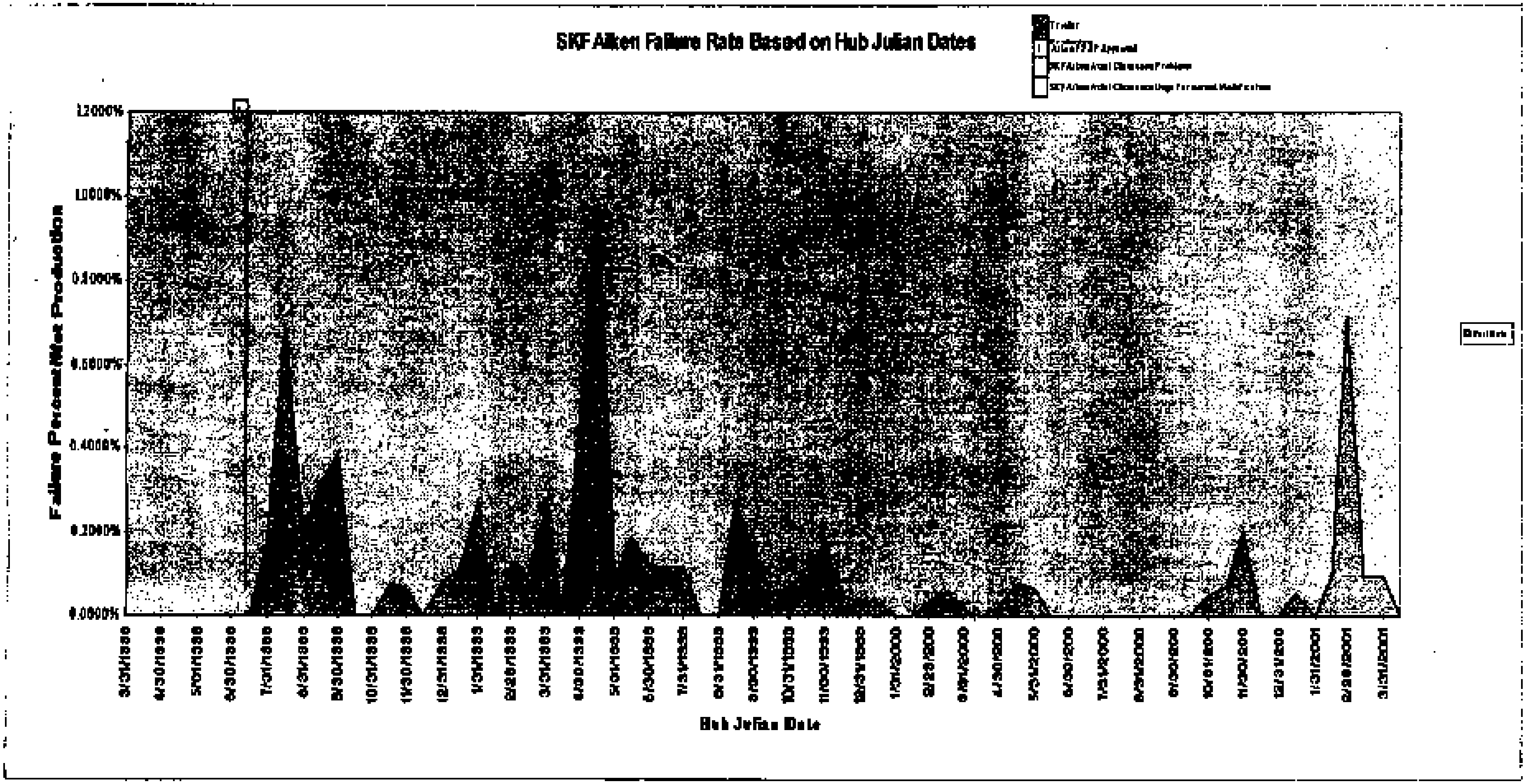
ArvinMeritor



SKF 001546

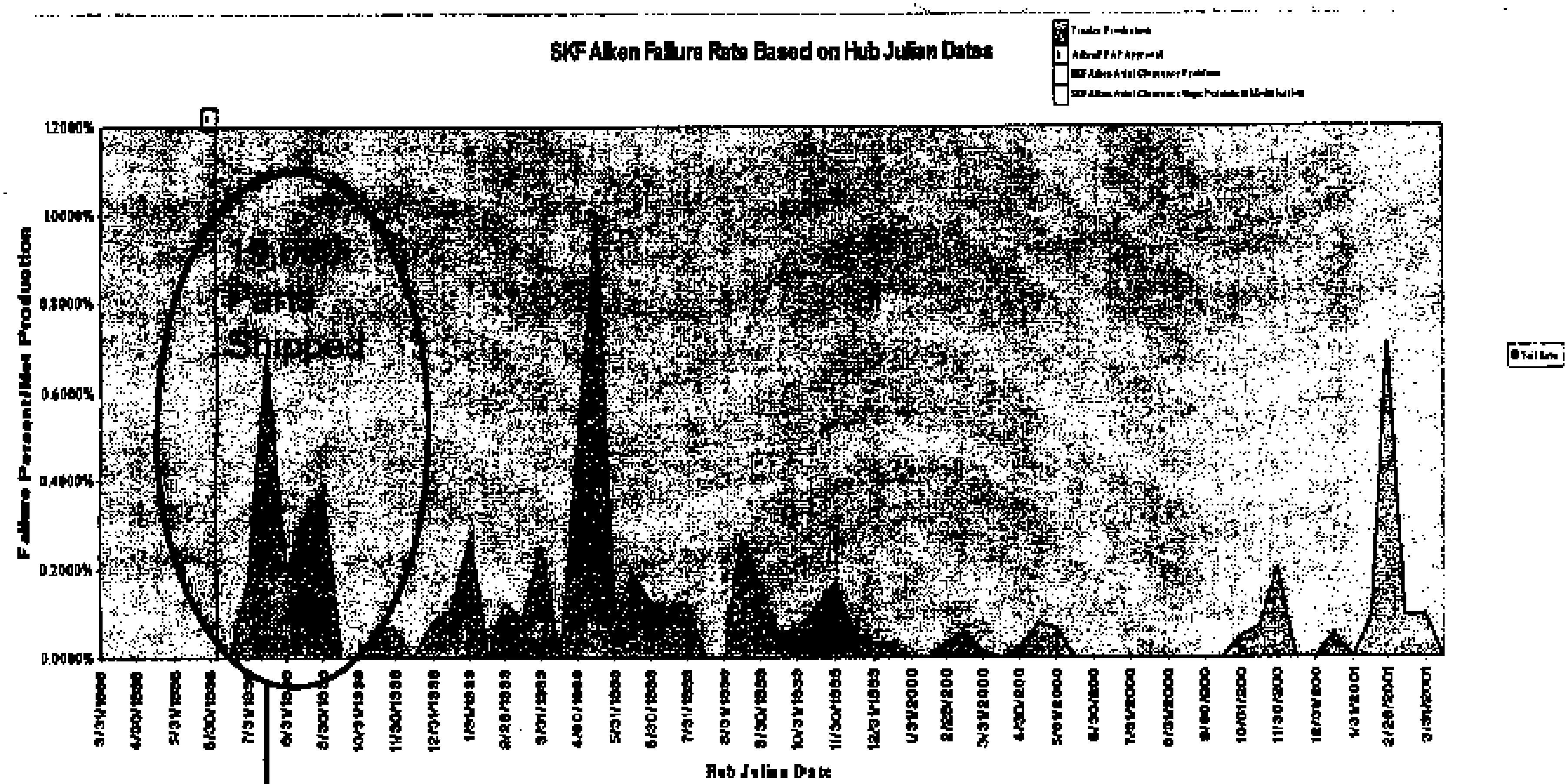

FF98X HUB Warranty Performance - Claims Thru March 2002
repairs per 100 axles
2.7
2.4
2.1
1.8
1.5
1.2
0.9
0.6
0.3
0
in-service month
1
2
3 mls
4
5
6 mls
7
8
9 mls
10
11
12mls
13
14
15
16
17
18mls
19
20
21
22
23
24mls
25
26
27
28
29
30mls
31
32
33
34
35
36mls
37
38
39
40
41
42
43
44
45
46
47
48
12mth AOP

SKF 001547



SKF Aiken Failure Rate Based on Hub Julian Dates
Trailer
1.2000%
1.0000%
0.8000%
0.6000%
0.4000%
0.2000%
0.0000%
Failure Percent/Net Production
Hub Julian Date

ArvinMeritor



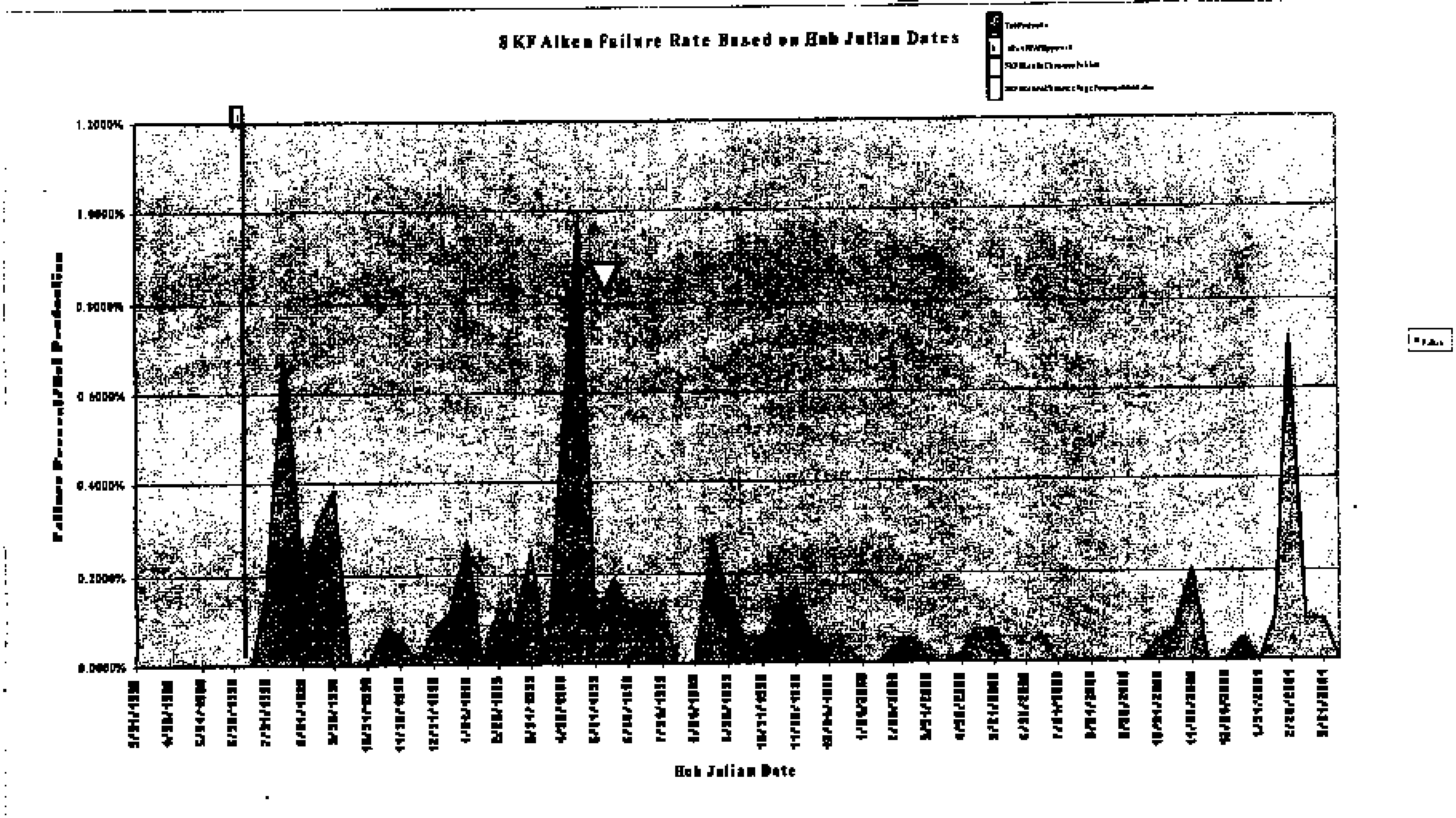
SKF 001549

Aiken Launch SKF Returned Parts

- Water
- Launch Issues / High Scrap Rate at SKF Aiken
- Hub Cap Deviations – Missing Hub Caps

SKF

ArvinMeritor



SKF 001551

Axial Clearance Gauge

- **Permanent Corrective Actions - Aug 20 1999**

Axial Clearance Corrections

- October 31, 1998 – Axial Clearance Gage air leak found

Corrective Action – Repaired Leak (October 31, 1998)

- January 21, 1999 – Axial Clearance Gage Diaphragm failure

Corrective Action – Replaced Diaphragm and quarantined approximately 2,000 bearings (January 21, 1999)

- May 31, 1999 - Axial Clearance Gage Diaphragm failure

Corrective Action – Replaced Diaphragm (May 31, 1999)

- August 20, 1999 – Bearing wobbles when rotated

Corrective Action – Axial Clearance Gage upper and lower bearings were replaced (August 20, 1999)

- **October 6, 1999 - Changed Mounting of Diaphragm to reduce wear**

- January 7, 2000 - Axial Clearance Failure

Corrective Action – Replaced Diaphragm (January 7, 2000)

- February 29, 2000 - Axial Clearance Gage Diaphragm replaced

Corrective Action – Replaced Diaphragm (February 29, 2000)

- **March 31, 2000 - Axial Clearance Gage retrofitted with new cylinder design replacing diaphragm.**

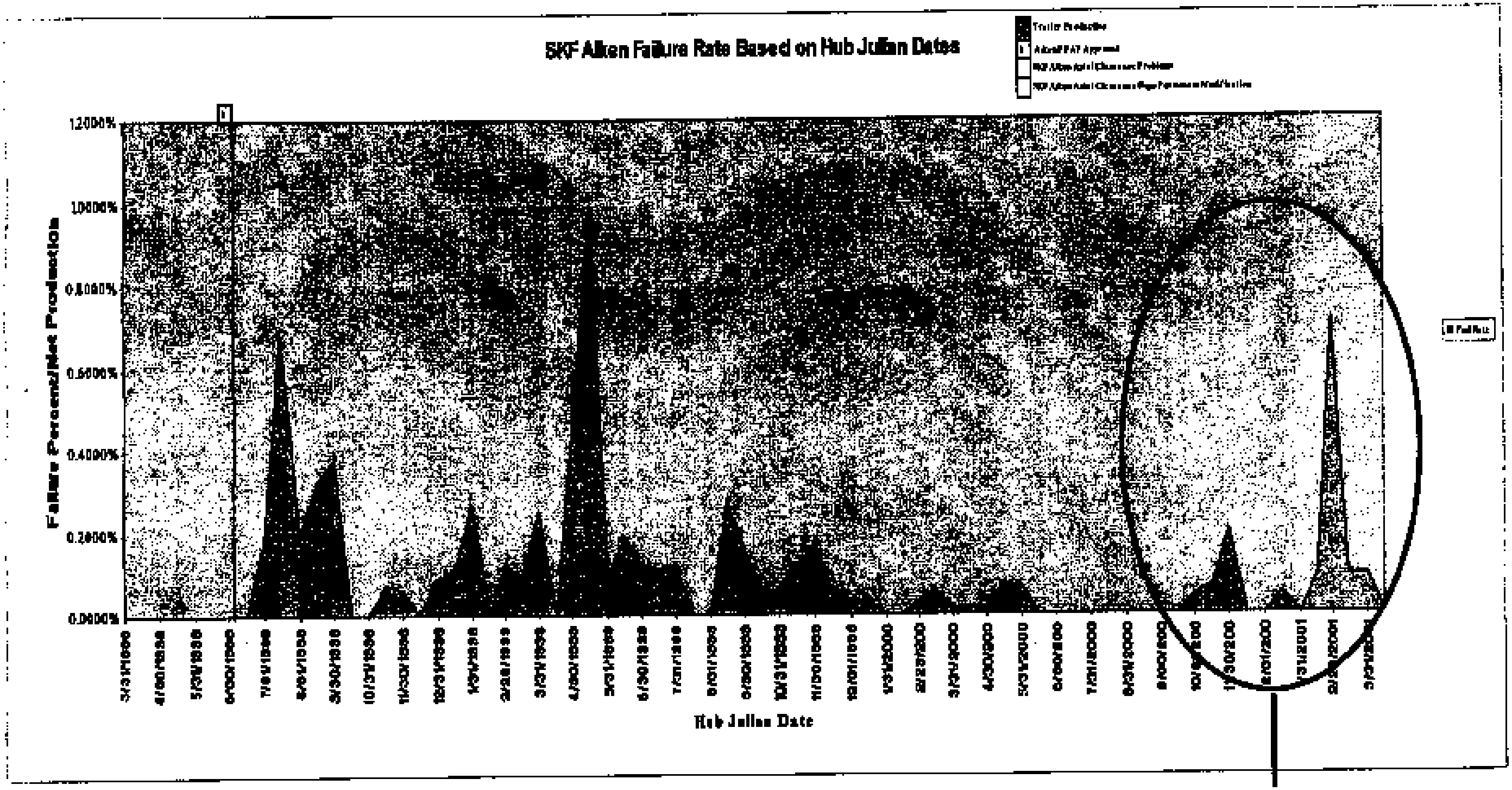
- April 27, 2000 –Centering Ball broke off of lower tooling

Corrective Action – Aligned Shaft (April 27, 2000)

- **June 6, 2000 - Axial Clearance Gage upper and lower bearings were replaced**

SKF 001552

ArvinMeritor



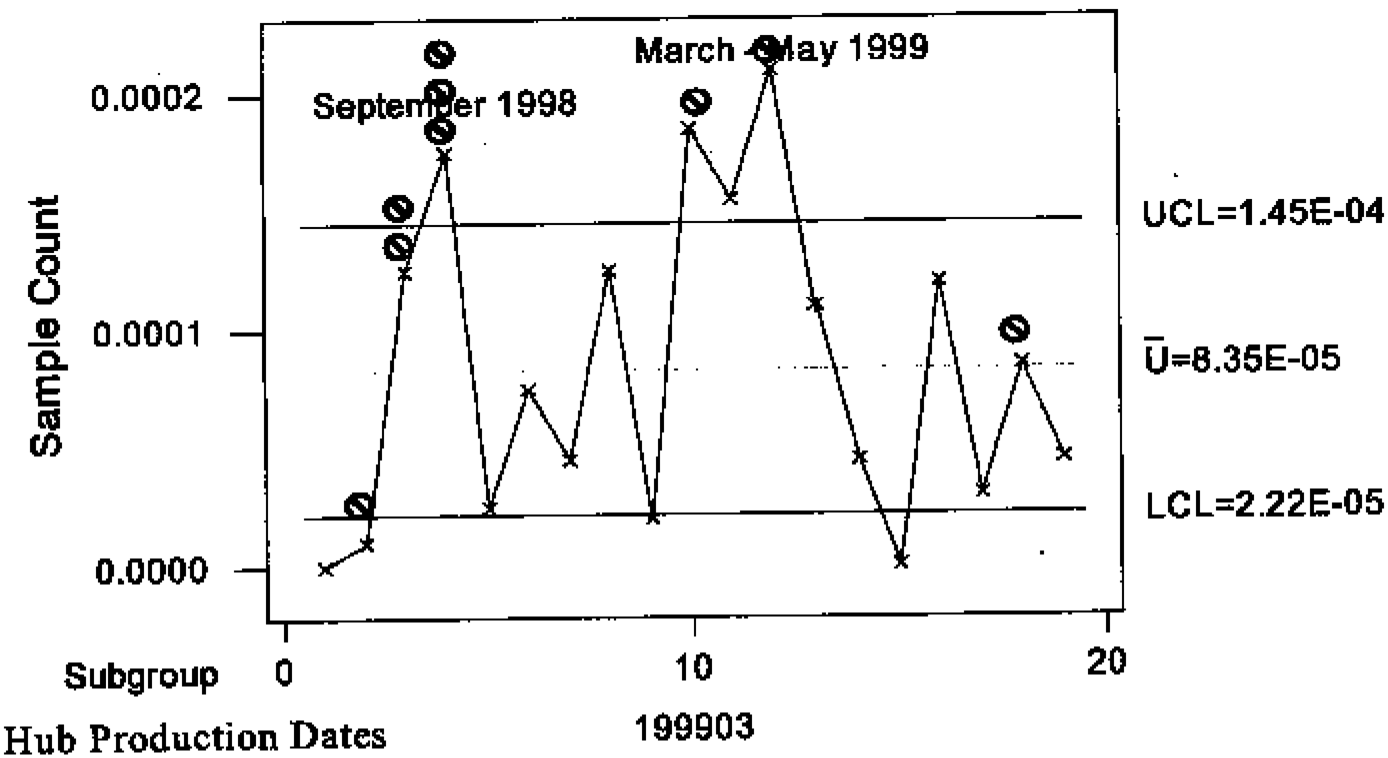
SKF 001553

Seal Molding Defect Rate < 2 %

Total Seals Manufactured 88,703

SKF

u Chart Count of Claims Vs Monthly Production
Steer Claims Only



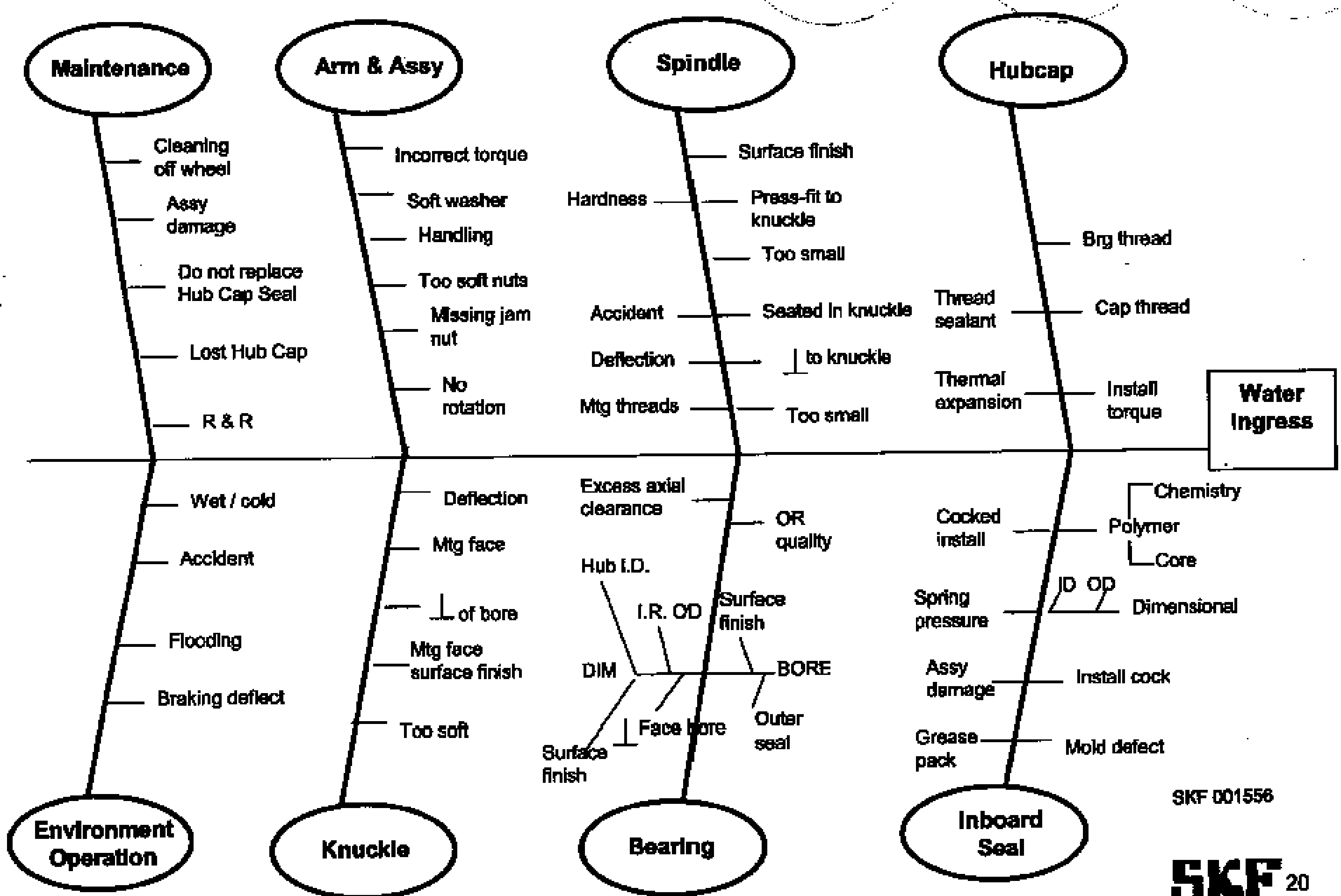
Issue Date of ARM Engineering Deviation Request <u>minus one month</u>.

Correlation study of hubcaps under deviation with high warranty periods

SKF 001554

Product Changes	Status	Addresses
Changed to R-Safe	Complete Apr 2000	Longer life seal that pumps outward
O-ring shoulder seal & MolyKote	Complete Jul 2001	Fretting Corrosion & Protects from Water
Changed to GW-Z	Complete Apr 2000	Higher Oil separation properties
Hubcap Re-design	Nov 2002	Lost hubcaps

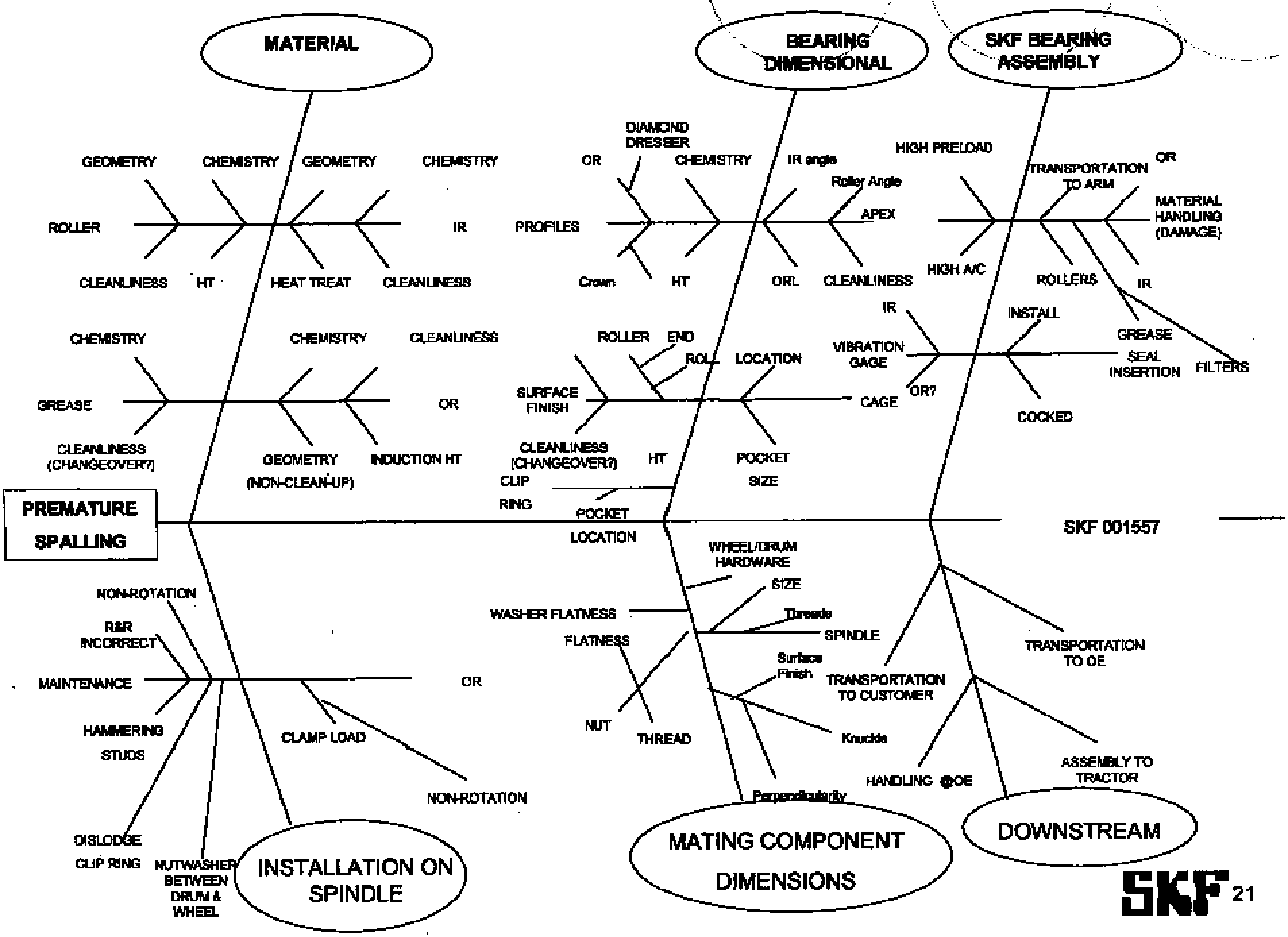
ArvinMeritor



SKF 001556

SKF

ArvinMeritor



SKF

ArvinMeritor

SKF 001556

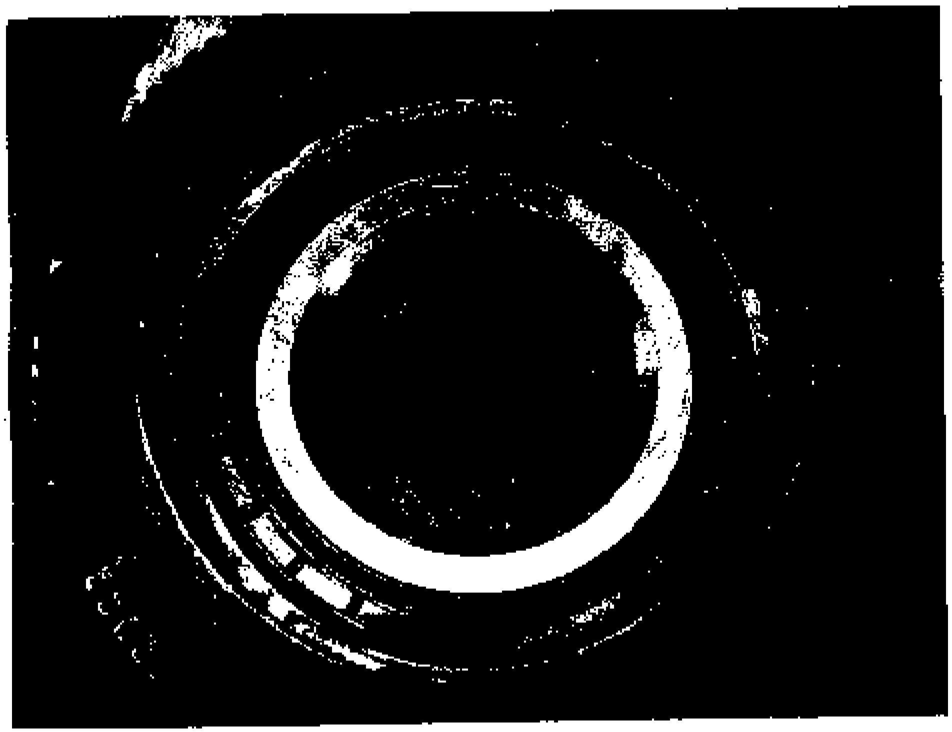
SKF 22

ArvinMeritor

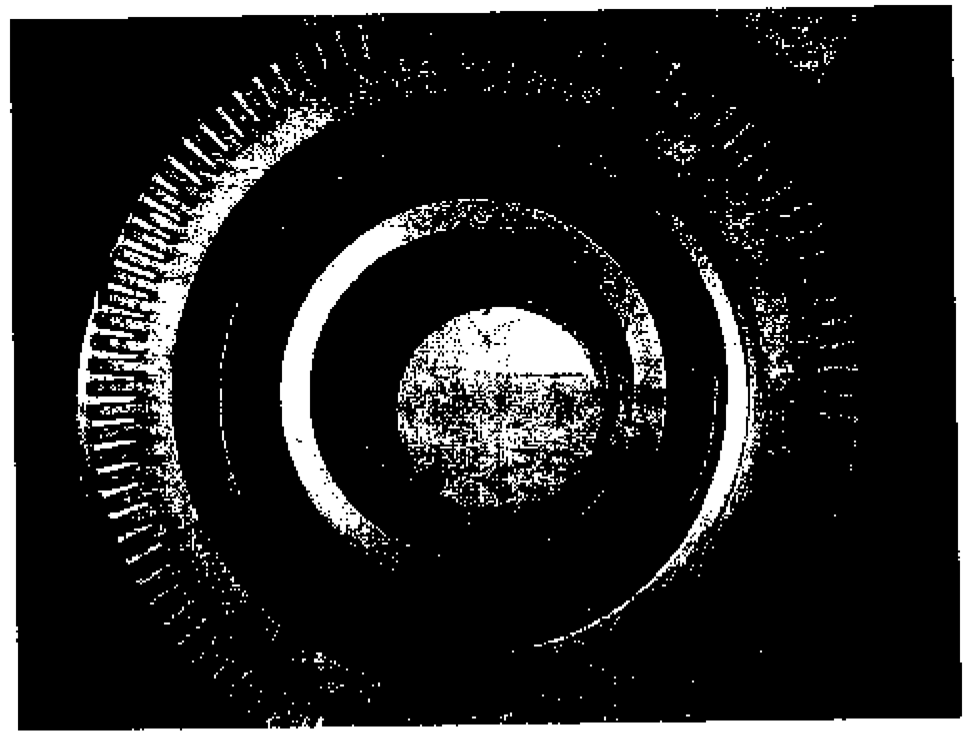
Process Changes	Status	Addresses
Auto-Rotate @ Arden	Complete Jul 2001	Clamp load, Seating of Rollers
Axial Clearance Gage	Complete	End Play, excessive pre-load
Supplier Audits		
No Hubcap Deviations		
•100 % leak test for Seals •Moved Process to Elgin from Bethelehem •Cleaned Mold stations	April 2002 April 2002 April, 2002	•Lip defects • Mold defects
Revised Heat Treat Process to make sure		
Grease fill rejections cannot be taken over		SKF 001559

ArvinMeritor

Pre - July, 2000

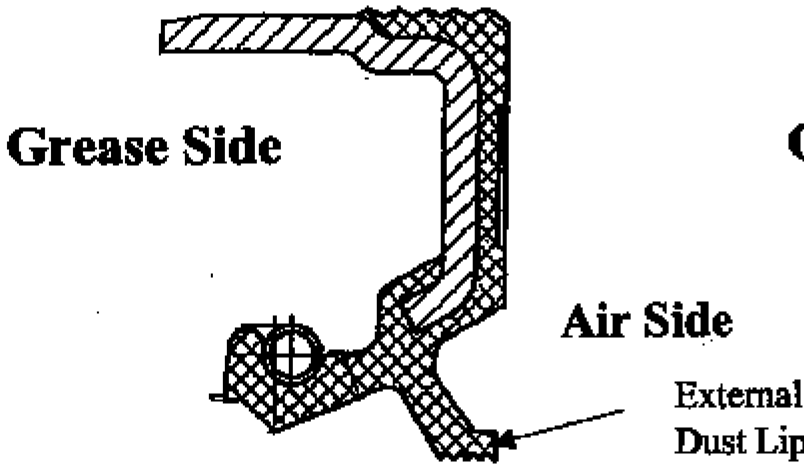


Post - July 2000



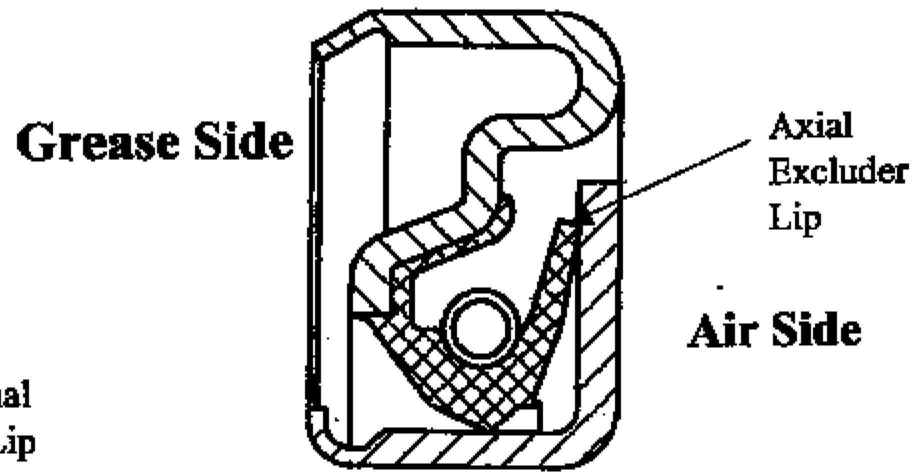
SKF 001560

ArvinMeritor



Fruedenburg Seal

- •Oil type seal – Pumps inward to keep oil inside bearing
- •External dust lip excludes dirt and water
- •Rubber bore sealing
- •Rides directly on ground inner ring shoulder
- •Initially chosen because of field success in Europe



CR R-Safe

- •Grease type seal – pumps outward to better exclude dirt, contaminants and water
- •Axial excluder lip has more positive sealing
- •Cartridge type seal with stainless steel counterface
- •BoreTite bore and ID sealing
- •Mud Slurry tests show 3X life compared to Fruedenburg Seal

R-Safe Seal Performance Advantages

- Seal function requirements
- No lubricant egress
- Protect against water, dust and mud
- Static sealing on outer diameter
- Corrosion protection
- Long life
- Good operating temperature range
- Capable of hub speeds
- Tolerance of misalignment
- Good resistance to cleaning fluids

SKF 001562

ArvinMeritor

SKF 001563

SKF Grease Selection & Development

Grease selection is singularly the most important and underestimated component that contributes to the longevity of the SKF LUNAR hubs

Below is a list of some of the properties and requirements that we have considered before making our optimum Grease Selection

- Grease Life
- Dropping Point
- Base Oil Viscosity
- Not Fatigue Promoting
- Corrosion Protection
- Mechanical Stability
- Optimum Oil Bleeding
- Compatibility with Seal Material
- High Temperature Performance
- Low Temperature Performance
- Anti-Wear Protection
- False Brinelling Protection
- Water Resistance
- Shear Stability
- Adhesive Properties
- Compatibility with Cage Material

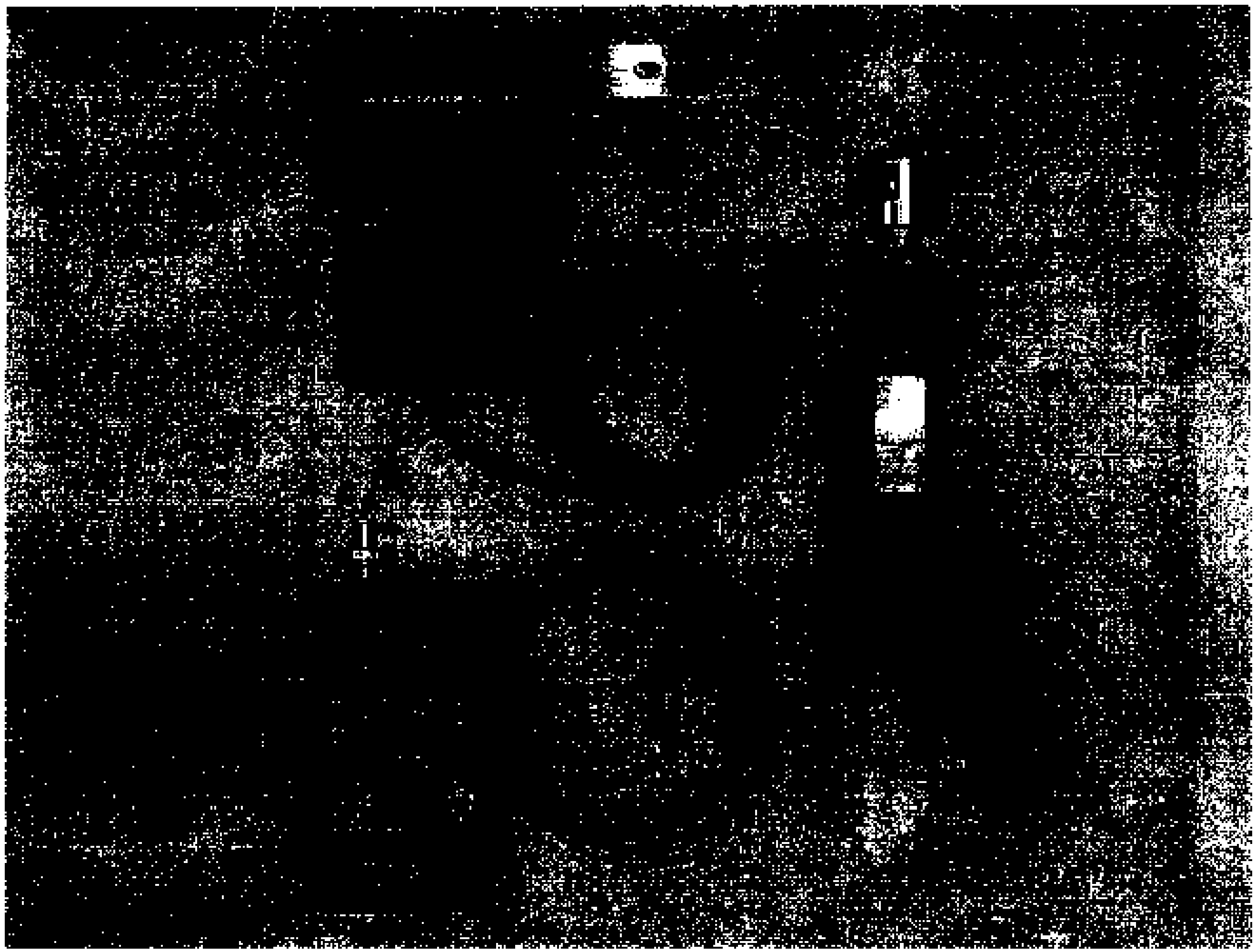
SKF 001564

We invite you to come to SKF's Aiken factory

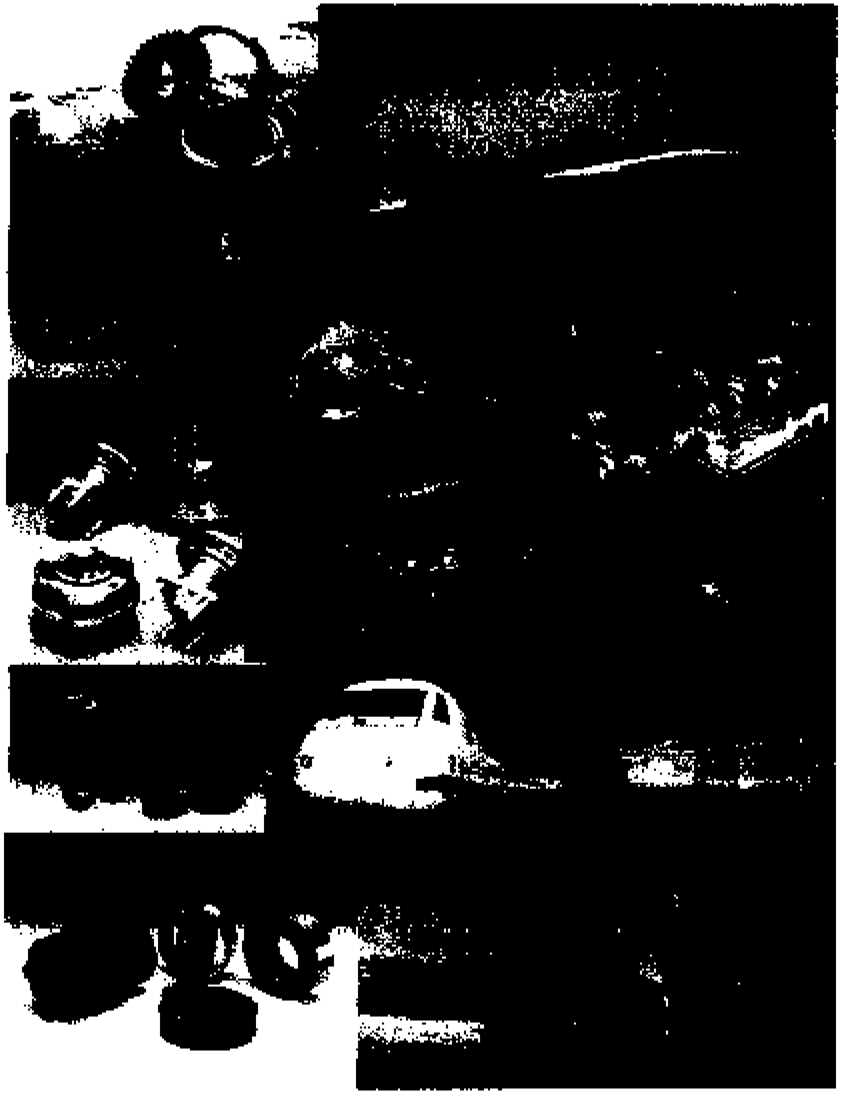
- Fully integrated and balanced manufacturing channel for THU 2 (Full Flange Version)
- Capacity: 300.000 Units/year
- In operation since: 1998
- A-TMU Assembly Channel under preparation
- Controlled Environment

SKF 001565

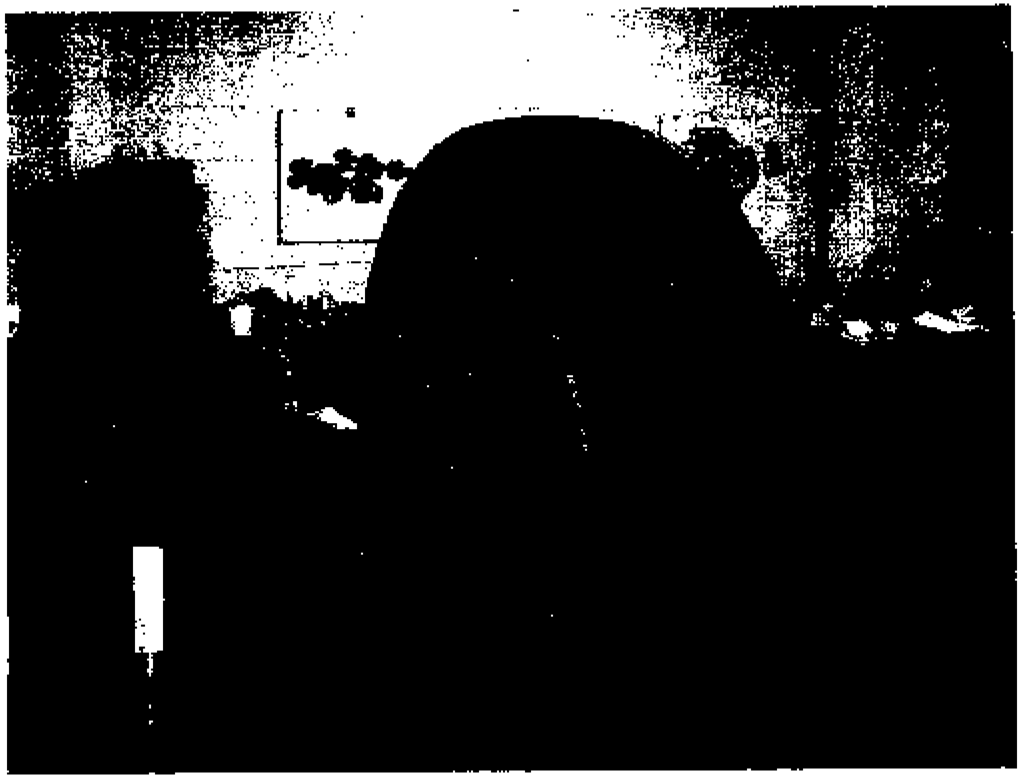
Vibration Monitoring

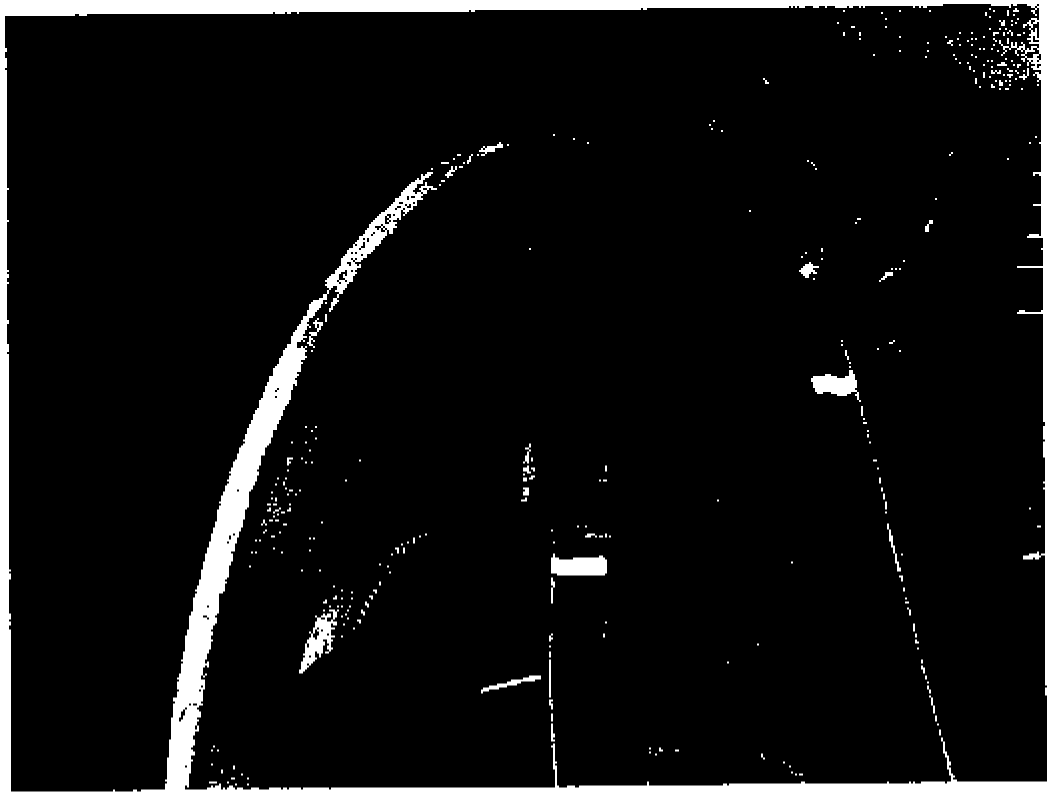


SKF Key Technologies

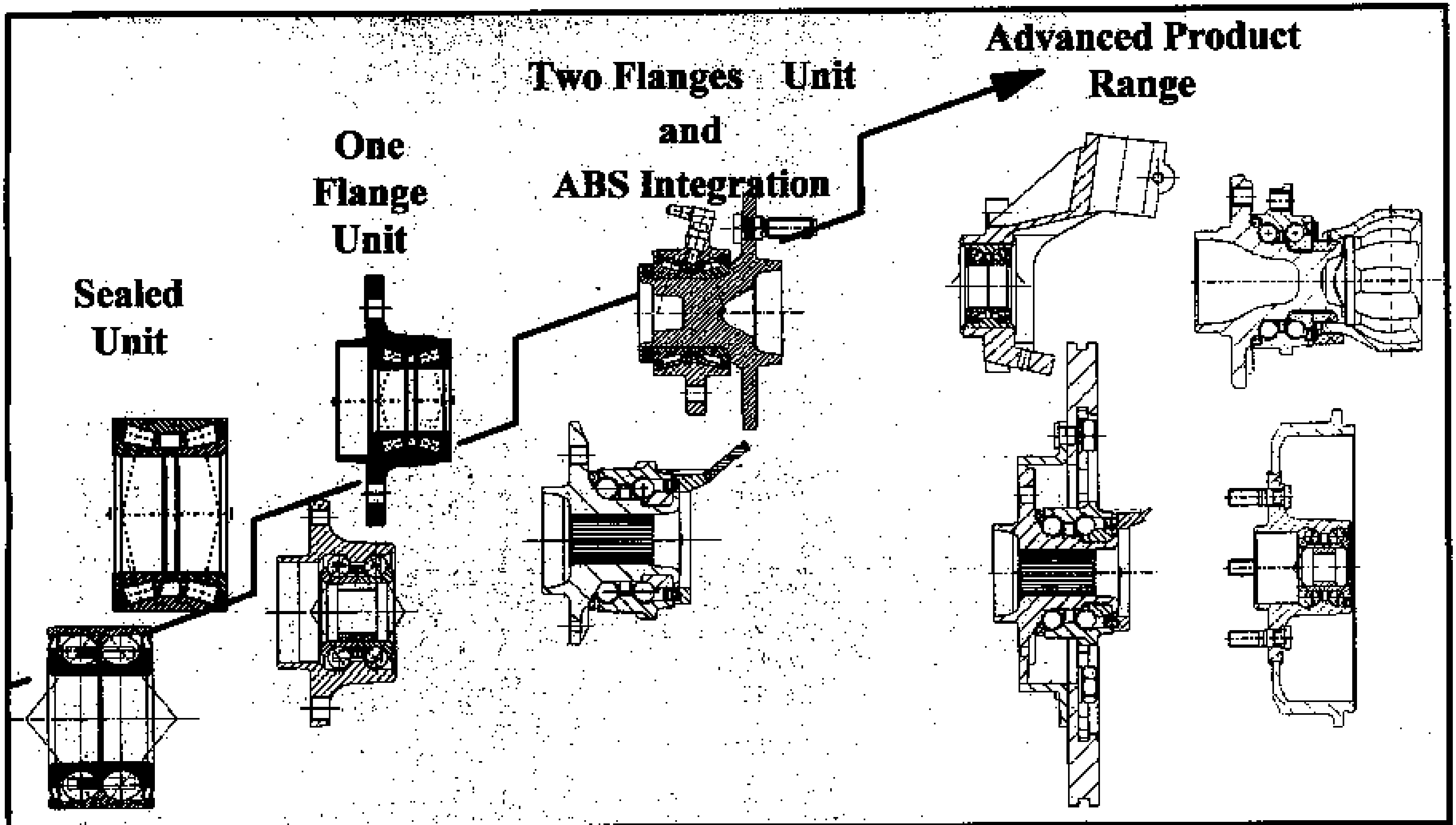


- Materials - steel / ceramics / polymers / elastomers
- Coatings
- Lubrication
- Manufacturing Technologies
- Mechatronics
- **Noise & Vibration / System Dynamics**
- Analytical Modelling
- Experimental Testing

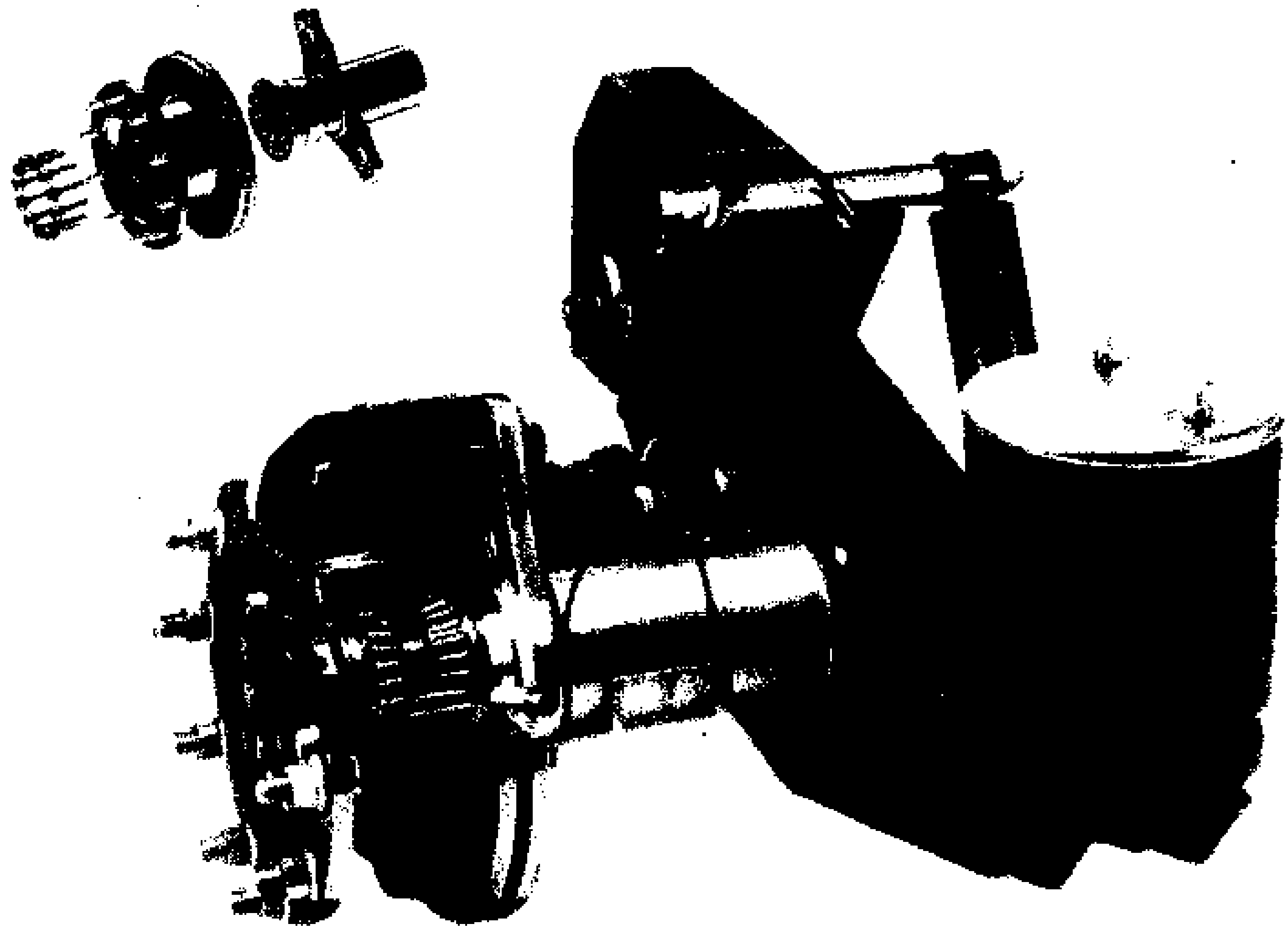




Future Products
Trucks to follow Cars



SAF Intradisc Plus

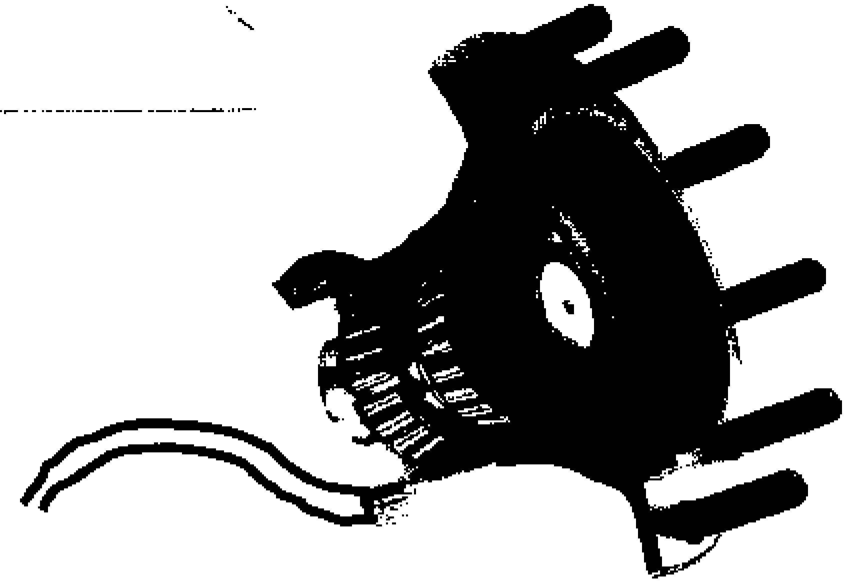


Disk Brake

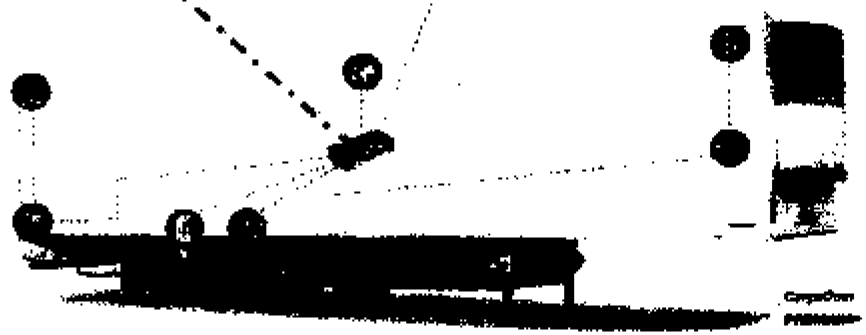
SKF 001572

ArvinMeritor

iTHU




Erfassung, Speicherung und Übersendung von Ortungs- und Betriebsdaten



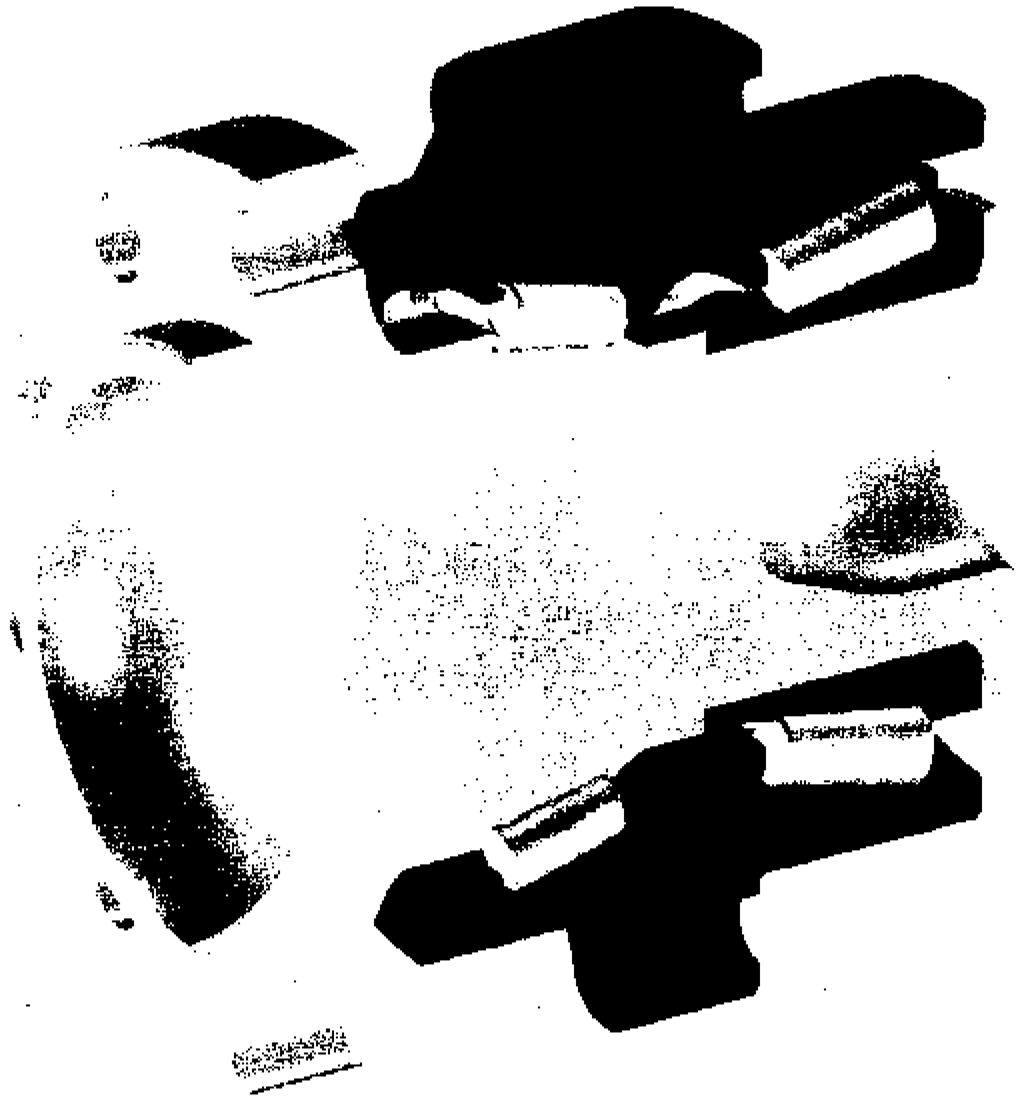
ArvinMeritor

Truck Corner Module

CONFIDENTIAL/
PENDING

ArvinMeritor

THU3 with turning IR



SKF 001575

Discussion

Main Topic

Robert J Bondy/DET/SKF
07/29 08:30 AM

Subject: Rough information for Freightliner

Category: Information

Ftl072902.ppt ARMvibmaterial.pp

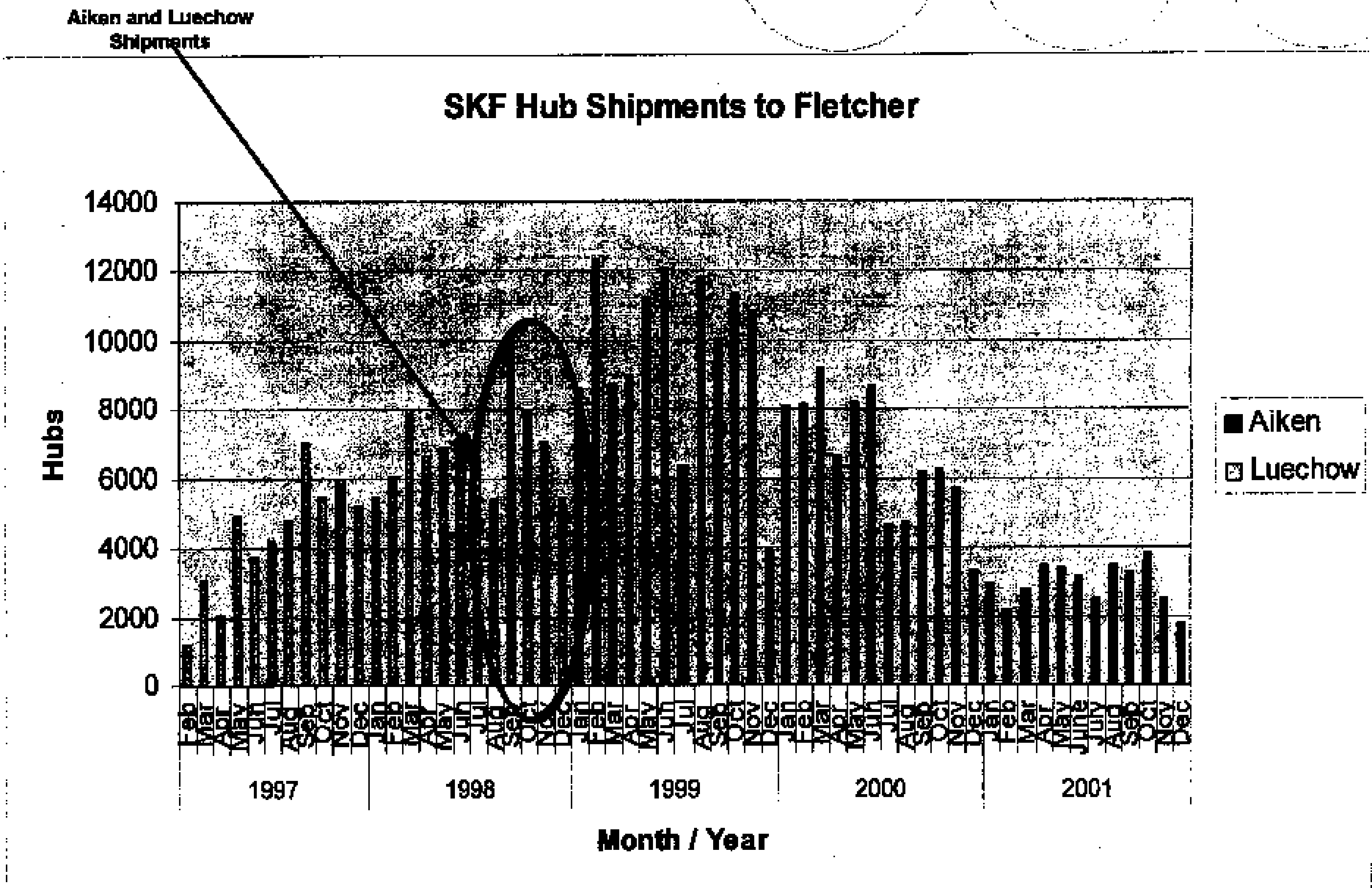
Presentation Title

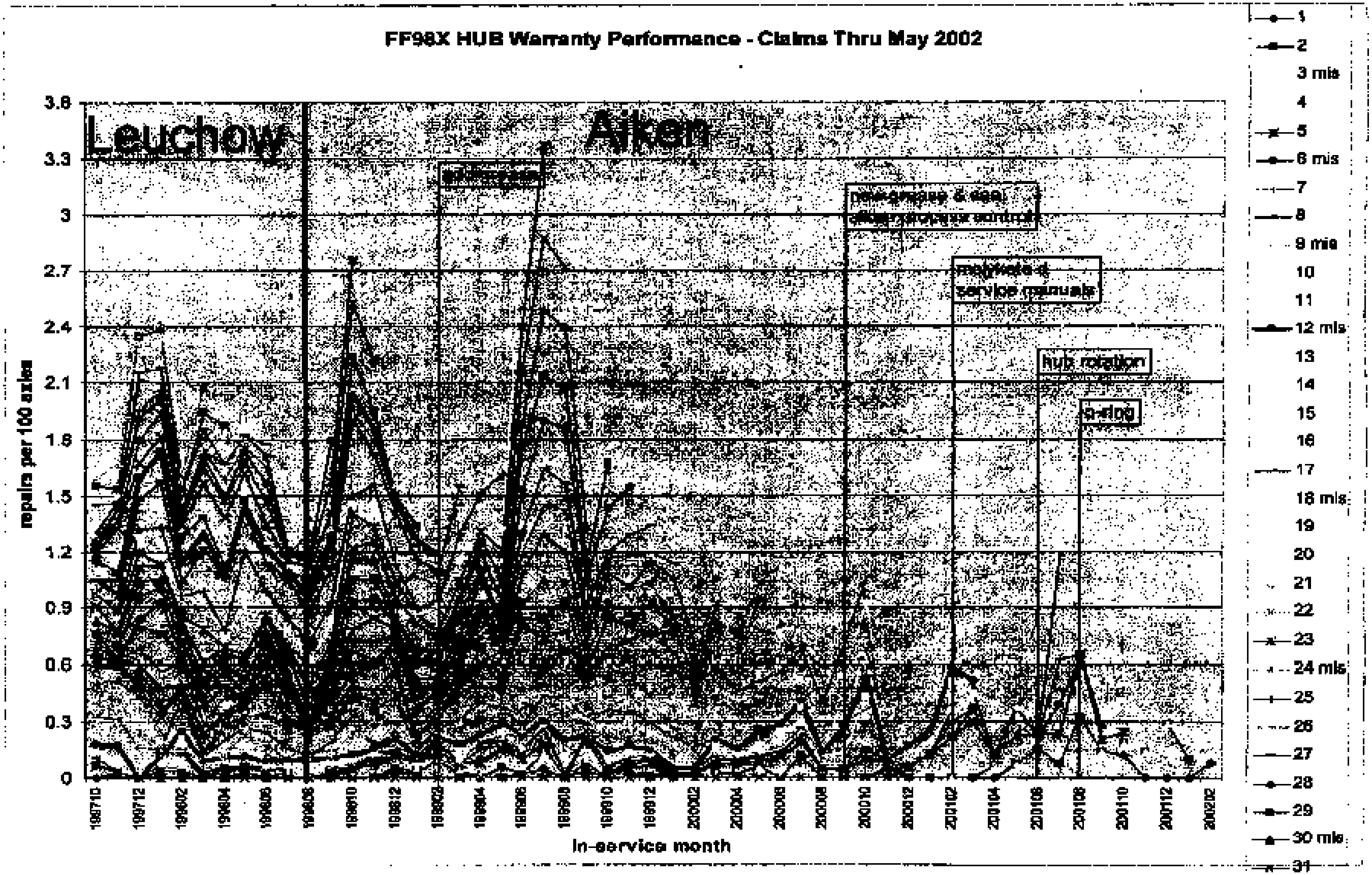
Subtitle

Presentation Date
Presentation Venue

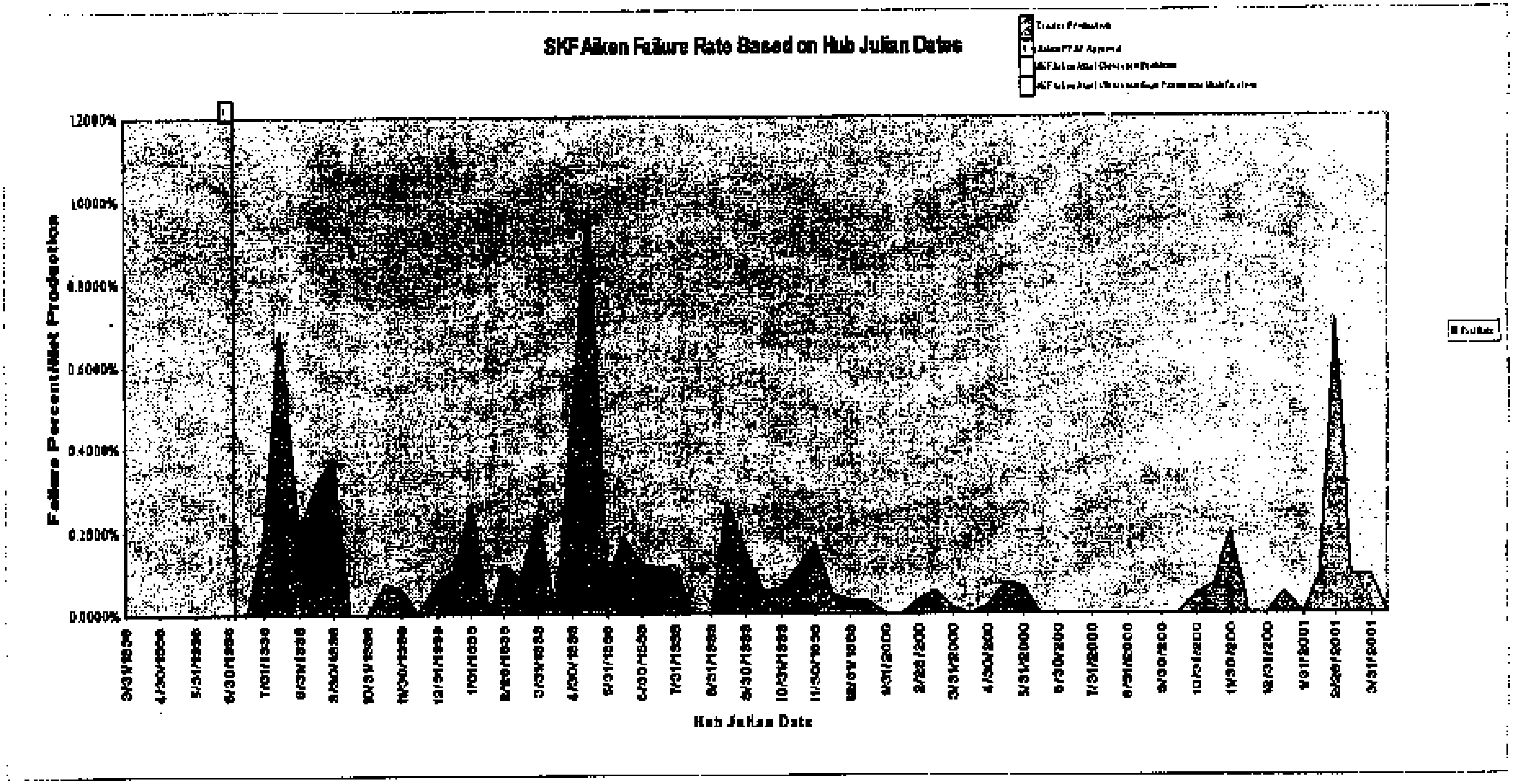
SKF 001577

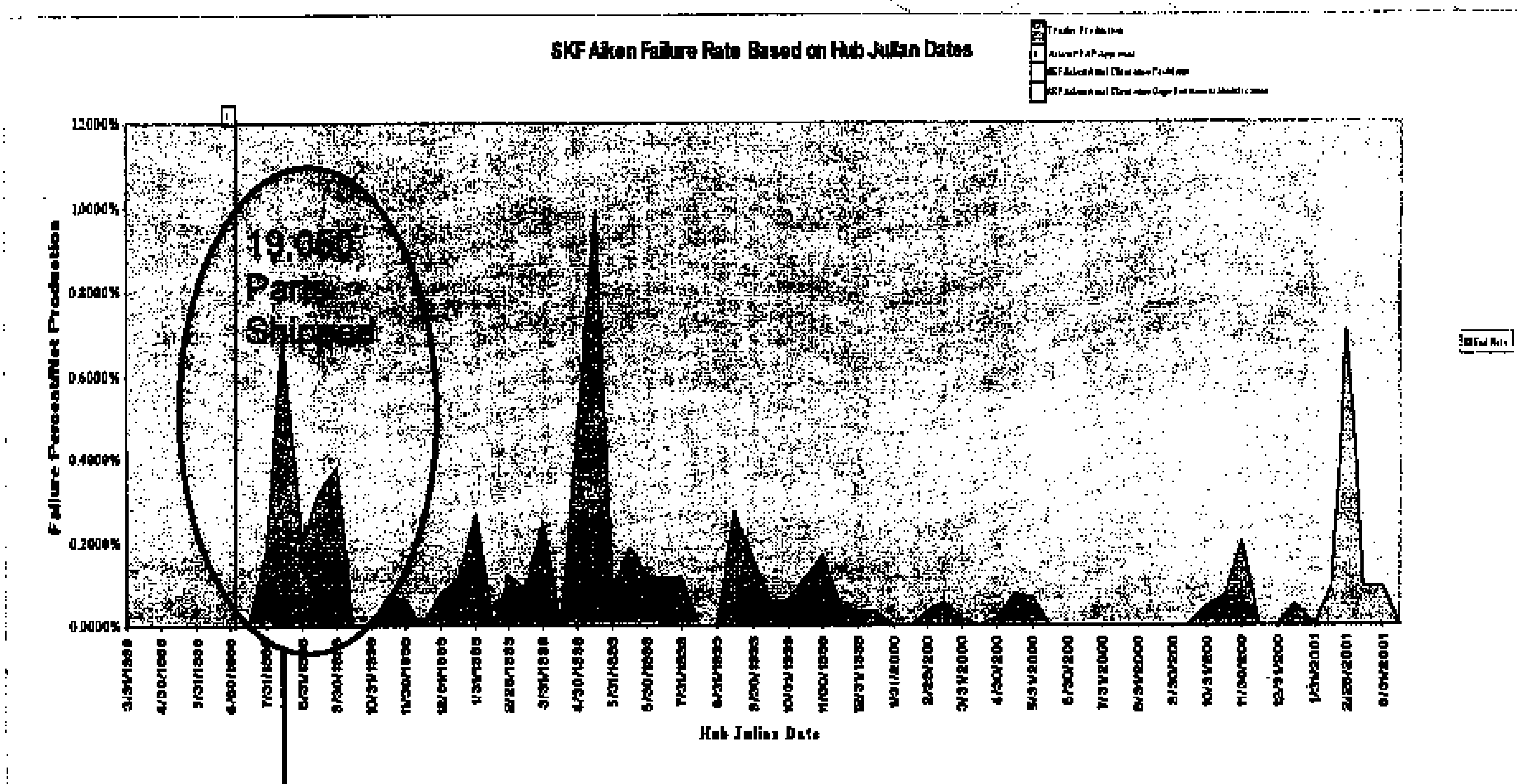
ArvinMeritor


Aiken and Luechow Shipments
SKF Hub Shipments to Fletcher
Hubs
14000
12000
10000
8000
6000
4000
2000
0
1997
1998
1999
2000
2001
Month / Year
Aiken
Luechow


FF98X HUB Warranty Performance - Claims Thru May 2002
Leuchow
Aiken
service manuals
hub rotation
3.6
3.3
3
2.7
2.4
2.1
1.8
1.5
1.2
0.9
0.6
0.3
0
repairs per 100 axles
In-service month
1
2
3 mls
4
5
6 mls
7
8
9 mls
10
11
12 mls
13
14
15
16
17
18 mls
19
20
21
22
23
24 mls
25
26
27
28
29
30 mls
31

ArvinMeritor



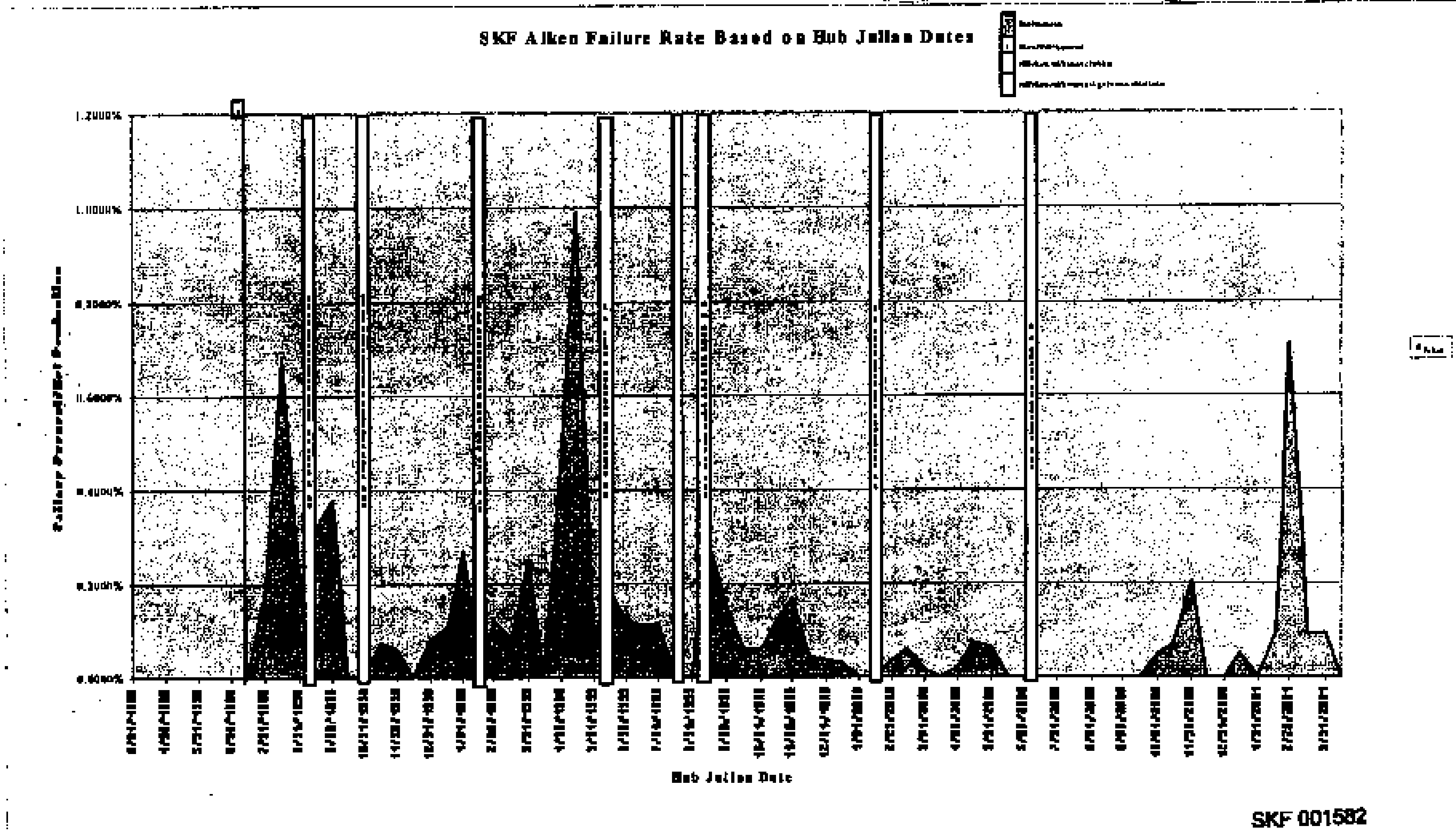


Aiken Launch SKF Returned Parts

- Water
- Launch Issues / High Scrap Rate at SKF Aiken
- Hub Cap Deviations -- Missing Hub Caps

SKF 001581

ArvinMeritor



SKF 001582

Axial Clearance Gauge

- Permanent Corrective Actions - Aug 20 1999

Axial Clearance Corrections

- October 31, 1998 – Axial Clearance Gage air leak found

Corrective Action – Repaired Leak (October 31, 1998)

- January 21, 1999 – Axial Clearance Gage Diaphragm failure

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Corrective Action – Replaced Diaphragm (January 7, 2000)

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Corrective Action – Aligned Shaft (April 27, 2000)

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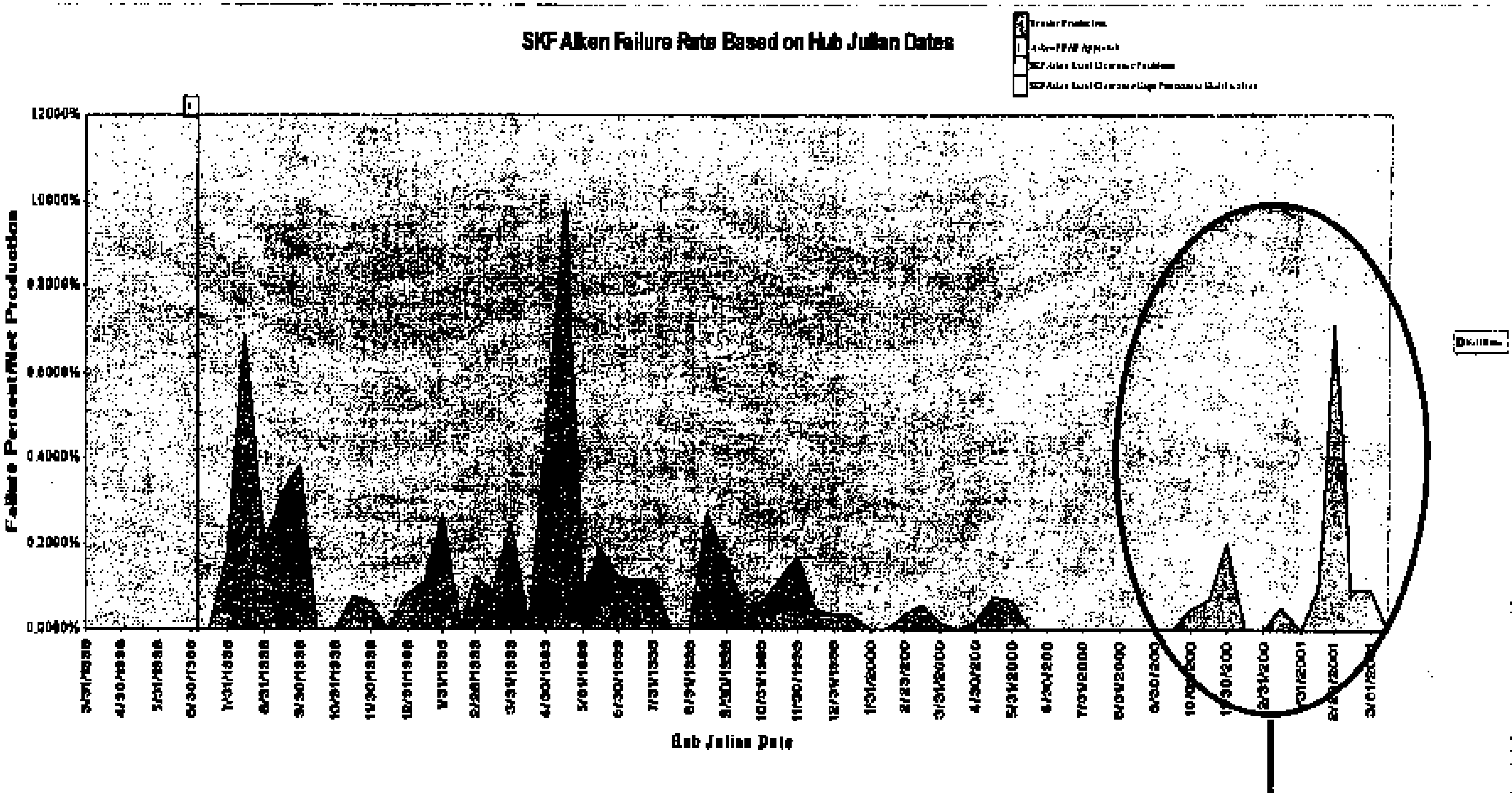
ArvinMeritor

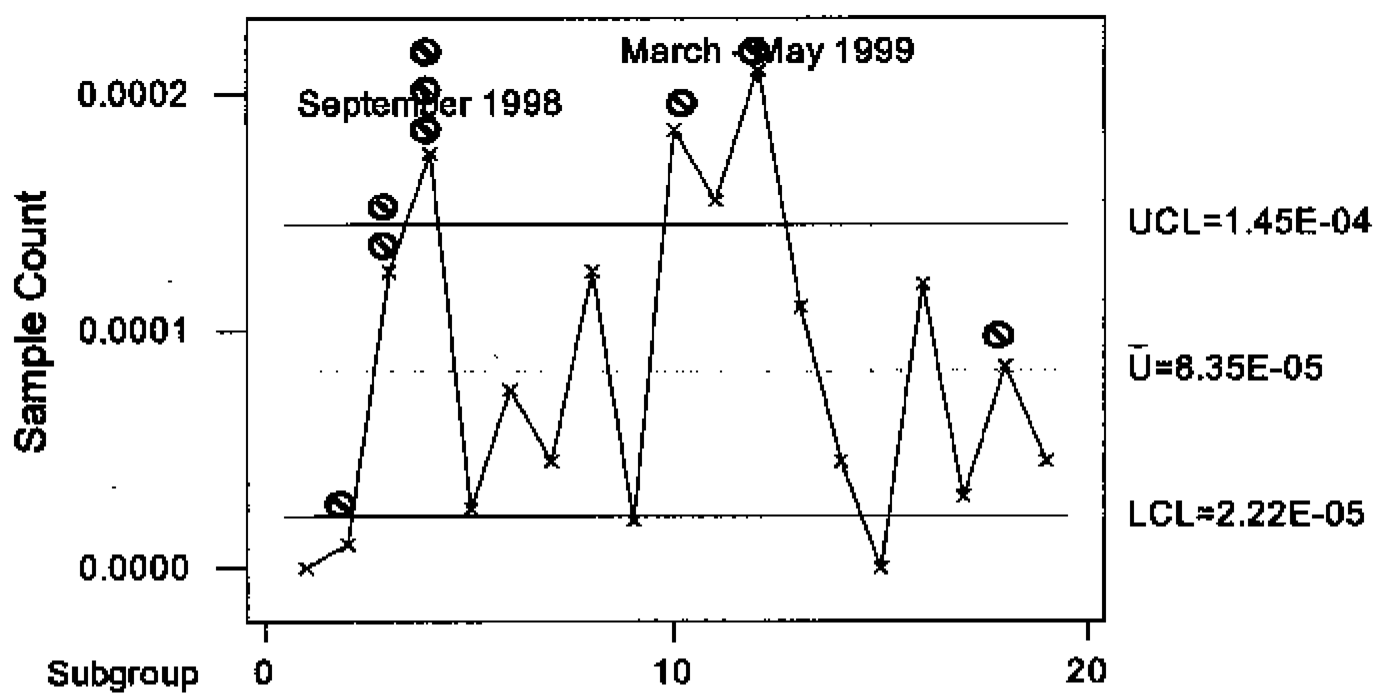


SKF 001584

Bethlehem Bleed rate < 2 %

Total Seals Manufactured 88,703

u Chart Count of Claims Vs Monthly Production
Steer Claims Only



Hub Production Dates 199903

Issue Date of ARM Engineering Deviation Request minus one month.

Correlation study of hubcaps under deviation with high warranty periods

Product Changes	Status	Addresses
Changed to R-Safe	Complete Apr 2000	Longer life seal that pumps outward
O-ring shoulder seal & MolyKote	Complete Jul 2001	Fretting Corrosion & Protects from Water
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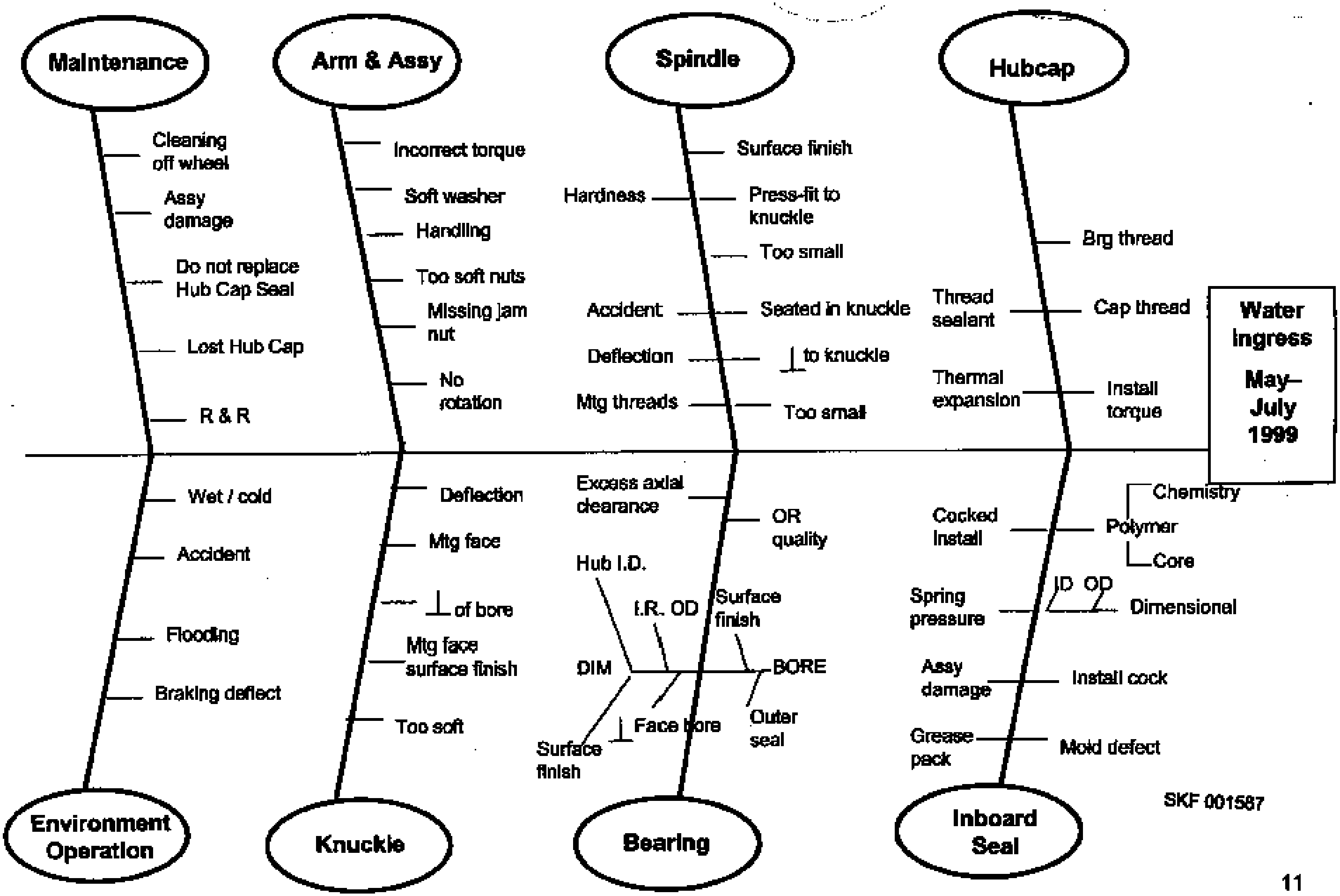
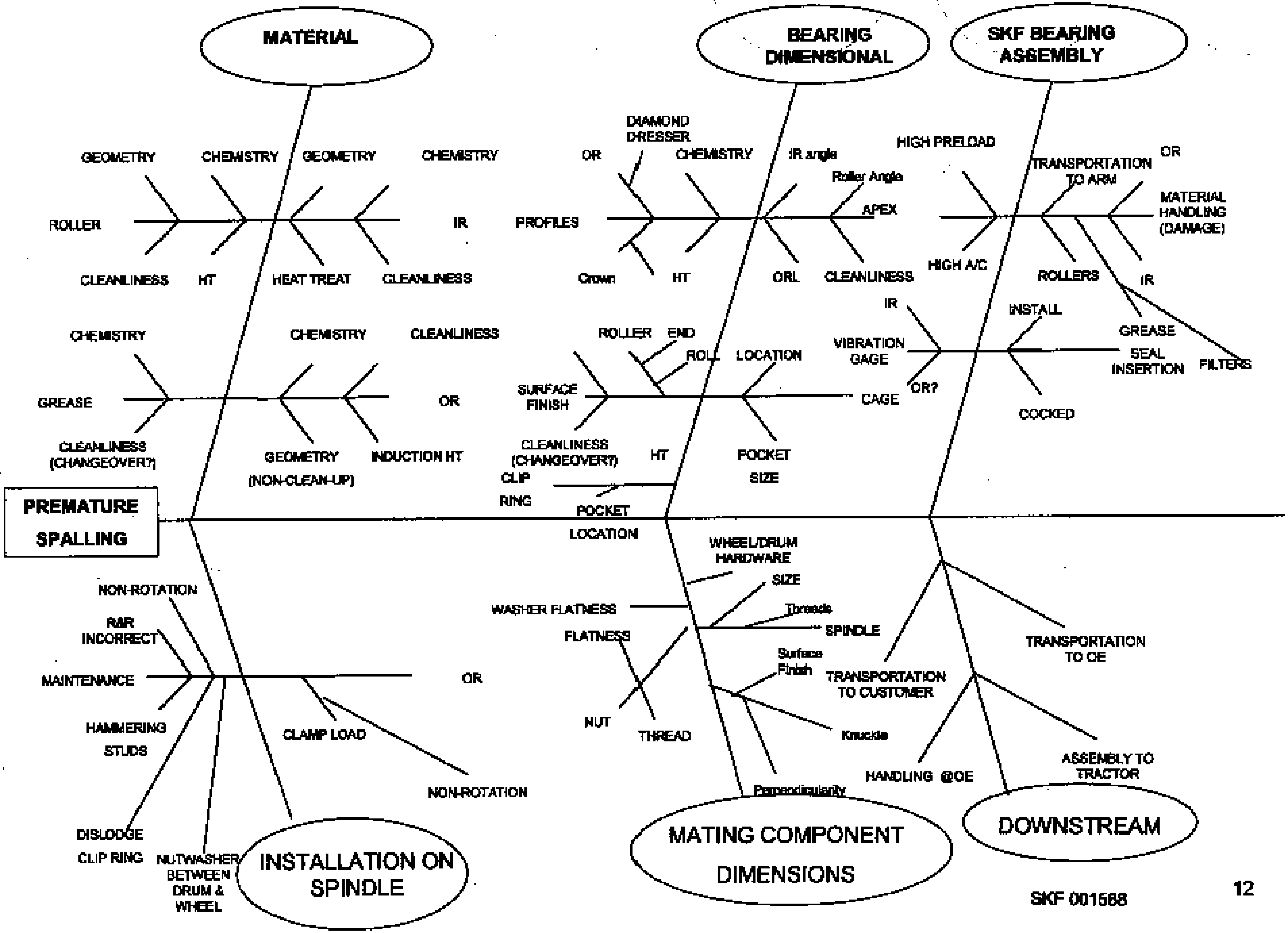
Hubcap Re-design	Nov 2002	Lost hubcaps


Maintenance
Cleaning off wheel
Assy damage
Do not replace Hub Cap Seal
Lost Hub Cap
R & R
Arm & Assy
Incorrect torque
Soft washer
Handling
Too soft nuts
Missing jam nut
No rotation
Spindle
Surface finish
Hardness
Press-fit to knuckle
Too small
Accident
Seated in knuckle
Deflection
⊥ to knuckle
Mtg threads
Too small
Hubcap
Brg thread
Thread sealant
Cap thread
Thermal expansion
Install torque
Water ingress
May–July 1999
Environment Operation
Wet / cold
Accident
Flooding
Braking deflect
Knuckle
Deflection
Mtg face
⊥ of bore
Mtg face surface finish
Too soft
Bearing
Excess axial clearance
OR quality
Hub I.D.
I.R. OD
Surface finish
DIM
BORE
⊥ Face bore
Outer seal
Surface finish
Inboard Seal
Chemistry
Cocked install
Polymer
Core
ID OD
Spring pressure
Dimensional
Assy damage
Install cock
Grease pack
Mold defect

SKF 001587

ArvinMeritor



Process Changes	Status	Addresses
Auto-Rotate @ Arden	Complete Jul 2001	Clamp load, Seating of Rollers
Axial Clearance Gage	Complete	End Play, excessive pre-load
Supplier Audits		
No Hubcap Deviations		
•100 % leak test for Seals •Moved Process to Elgin from Bethelehem •Cleaned Mold stations	April 2002 April 2002 April, 2002	•Lip defects • Mold defects
Revised Heat Treat Process to make sure		
Grease fill rejections cannot be taken over		

Steer Axle System

Consists of:

- Bearing System
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- Knuckle
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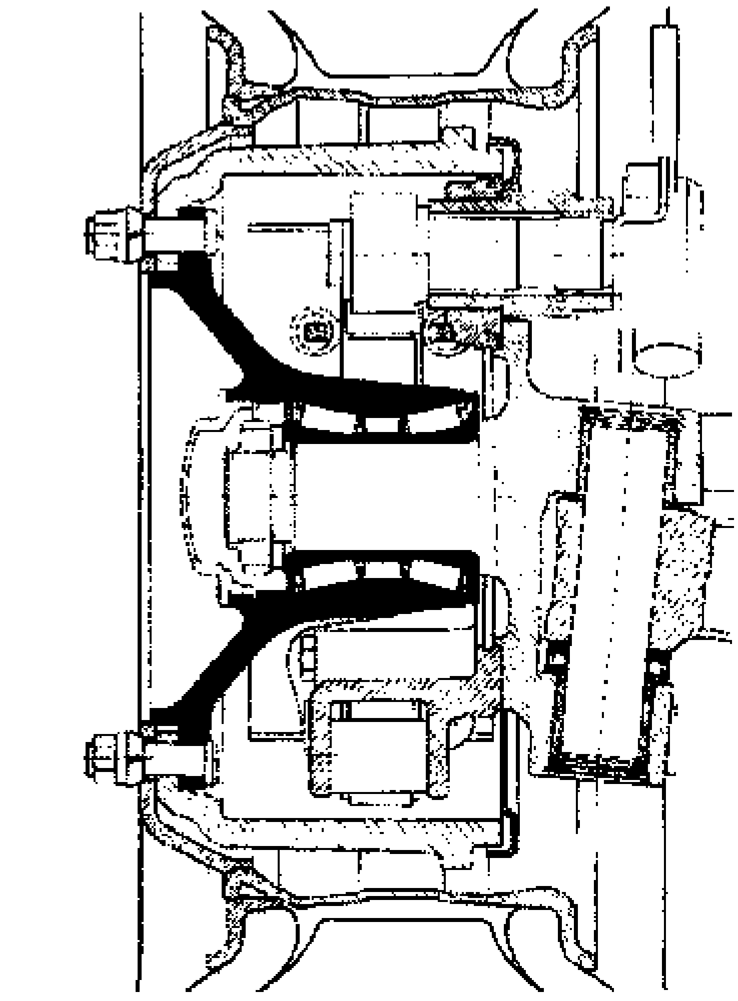
- Mounting Hardware
- Hub Cap



Bearing System

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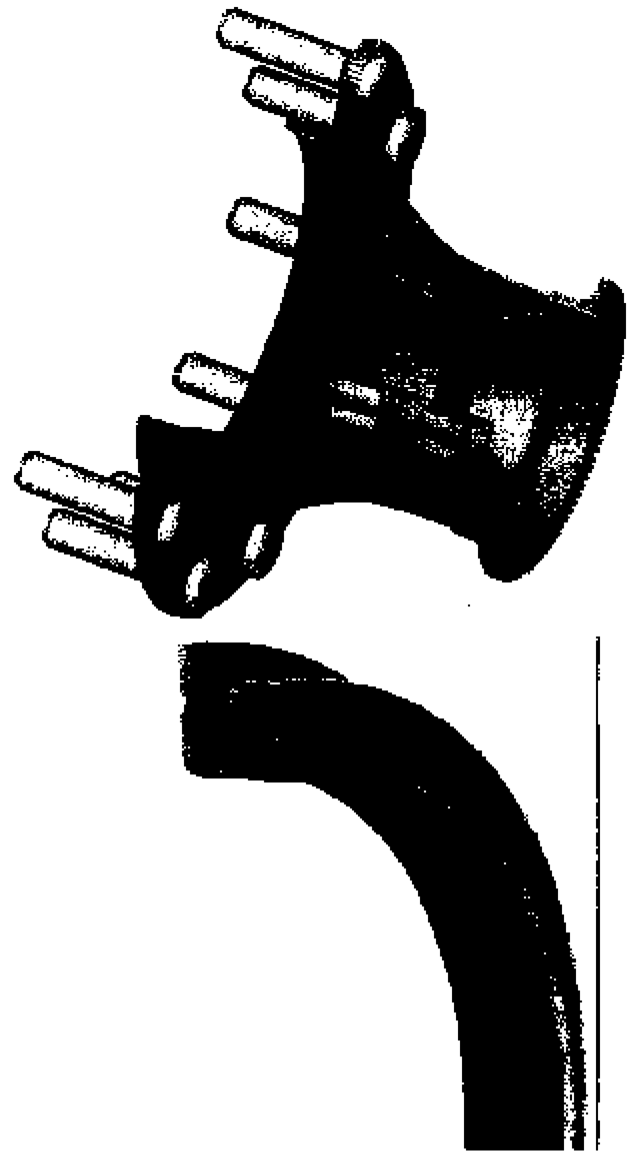
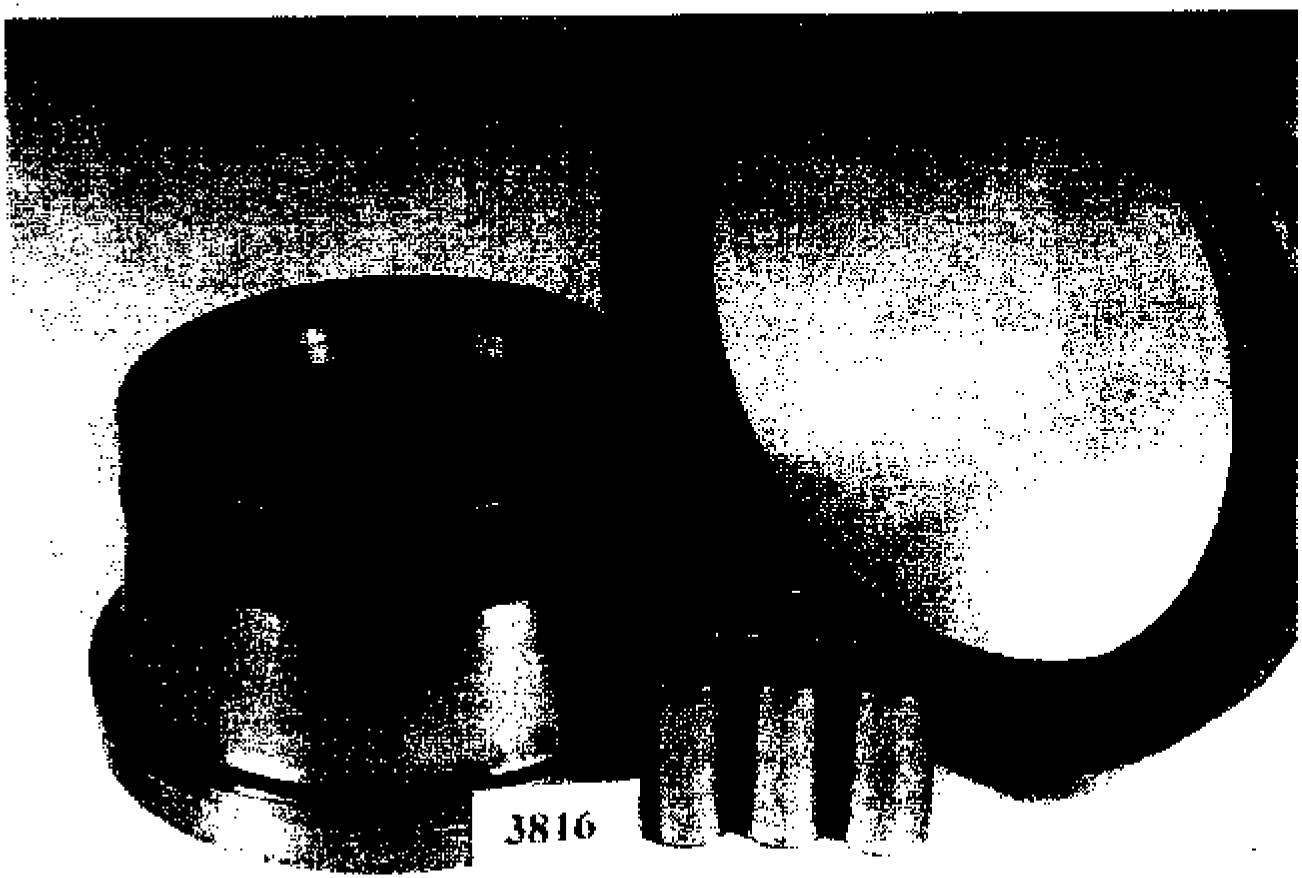


SKF 001592

Expectations of the Steer System

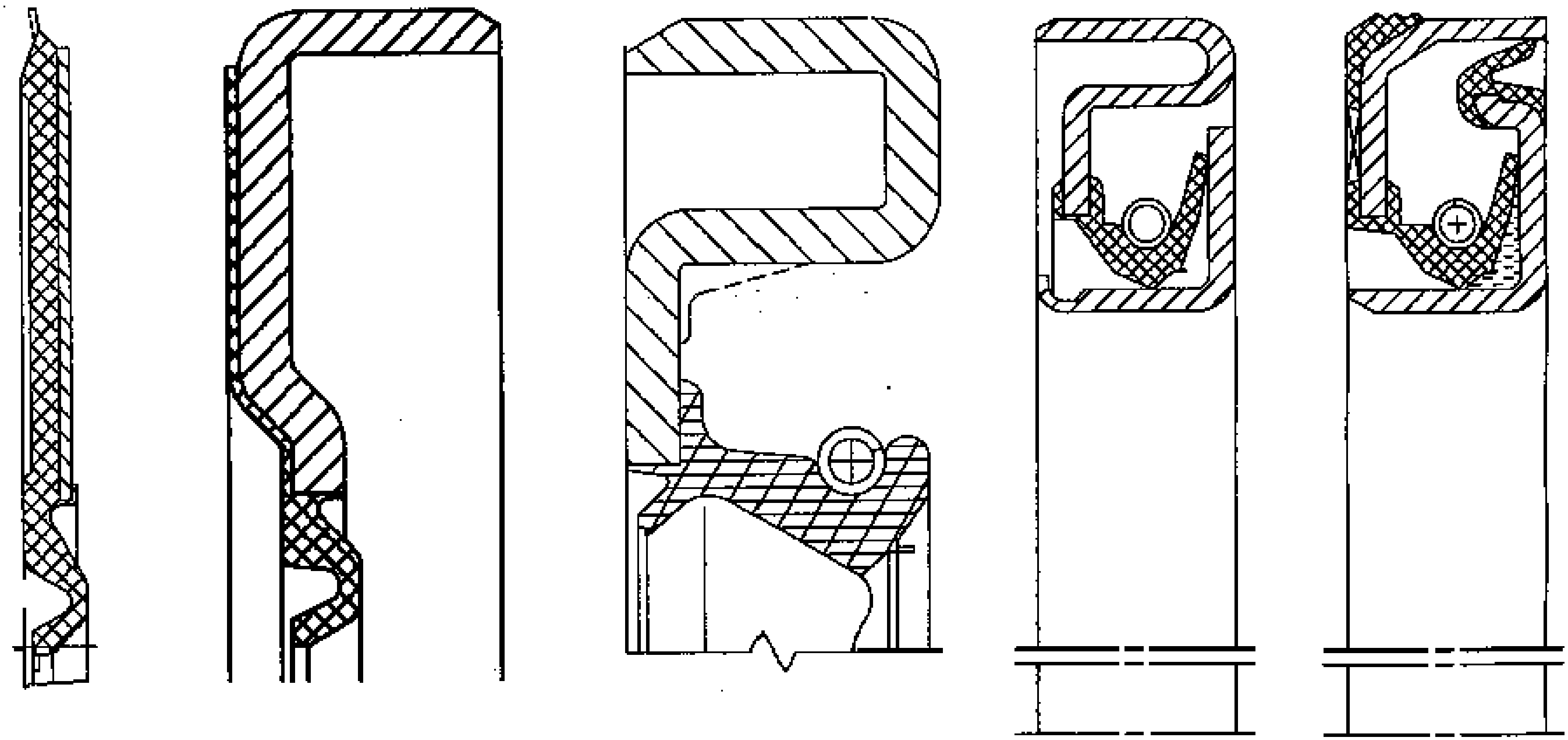


After 876,000 Miles

SKF 001594

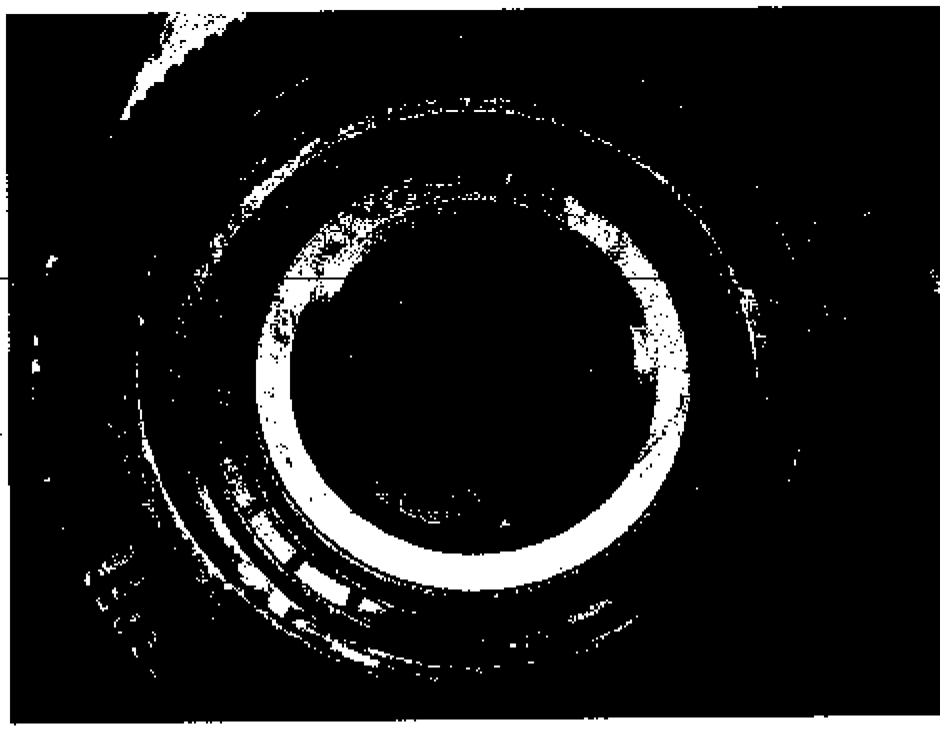
ArvinMeritor

Seal Designs

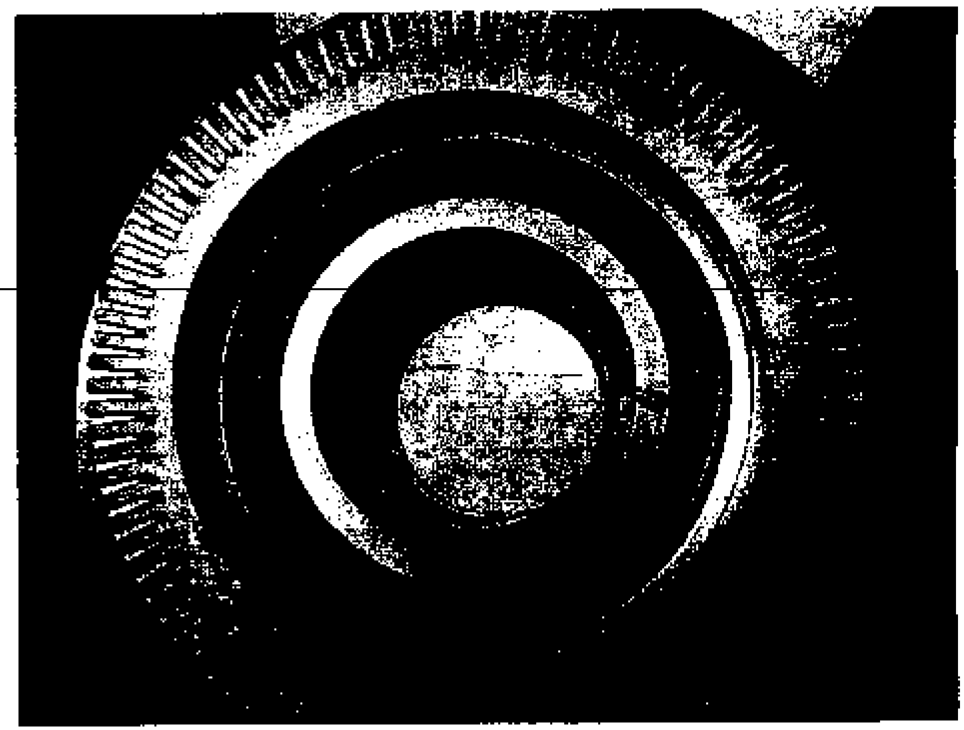


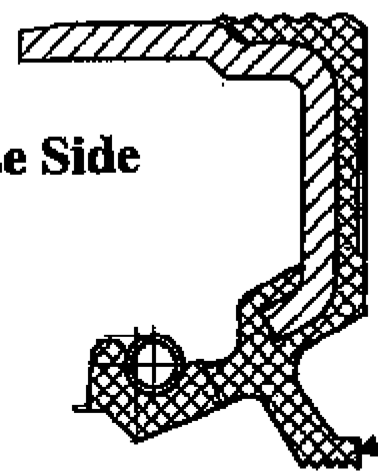
Lipseal | Lipseal | Garter-seal | R-Safe | R-Safe++

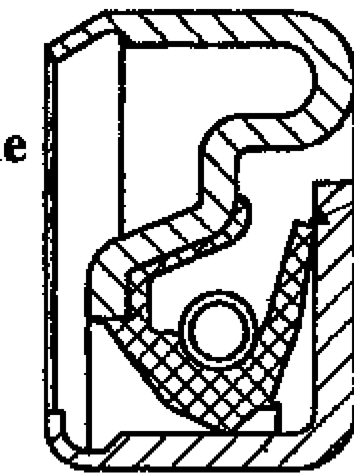
Pre - July, 2000



Post - July 2000







Fruedenburg Seal

- Oil type seal – Pumps inward to keep oil inside bearing
- External dust lip excludes dirt and water
- Rubber bore sealing
- Rides directly on ground inner ring shoulder
- Initially chosen because of field success in Europe

CR R-Safe

- Grease type seal – pumps outward to better exclude dirt, contaminants and water
- Axial excluder lip has more positive sealing
- Cartridge type seal with stainless steel counterface
- BoreTite bore and ID sealing
- Mud Slurry tests show 3X life compared to Fruedenburg Seal

R-Safe Seal Performance Advantages

- Seal function requirements
- No lubricant egress
- Protect against water, dust and mud
- Static sealing on outer diameter
- Corrosion protection
- Long life
- Good operating temperature range
- Capable of hub speeds
- Tolerance of misalignment
- Good resistance to cleaning fluids

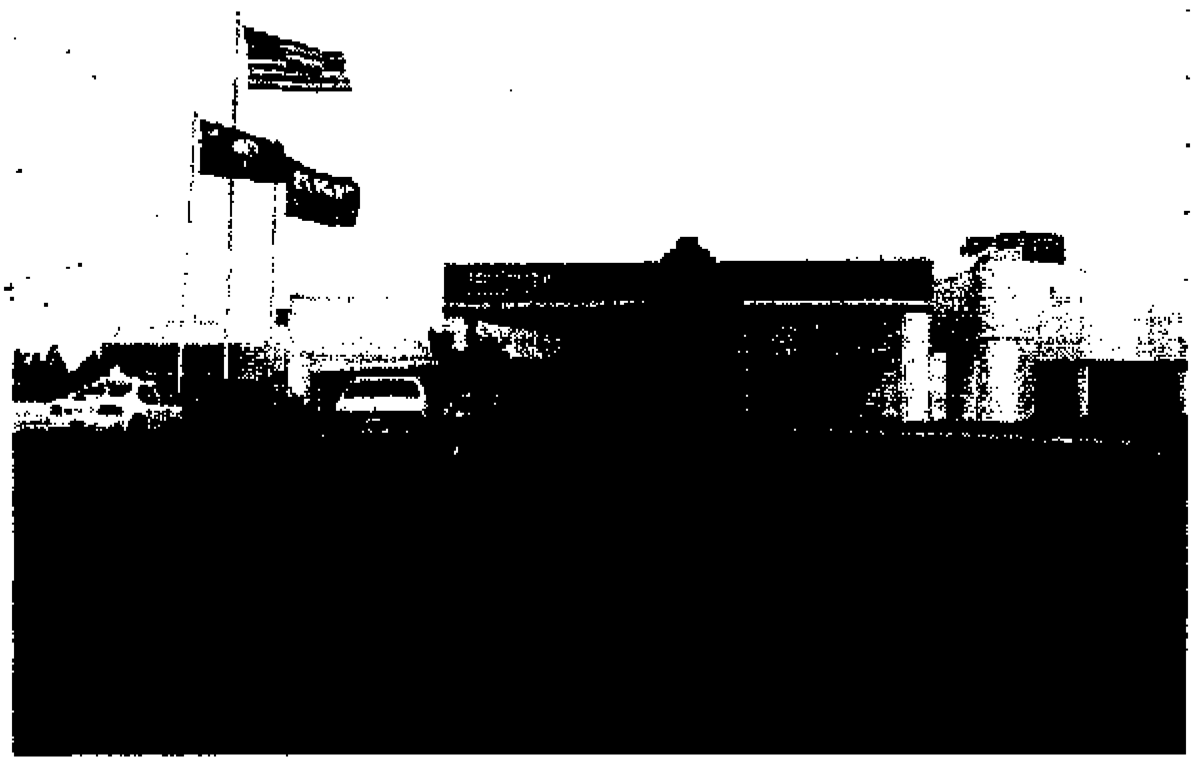
SKF Grease Selection & Development

Grease selection is singularly the most important and underestimated component that contributes to the longevity of the SKF LUNAR hubs

Below is a list of some of the properties and requirements that we have considered before making our optimum Grease Selection

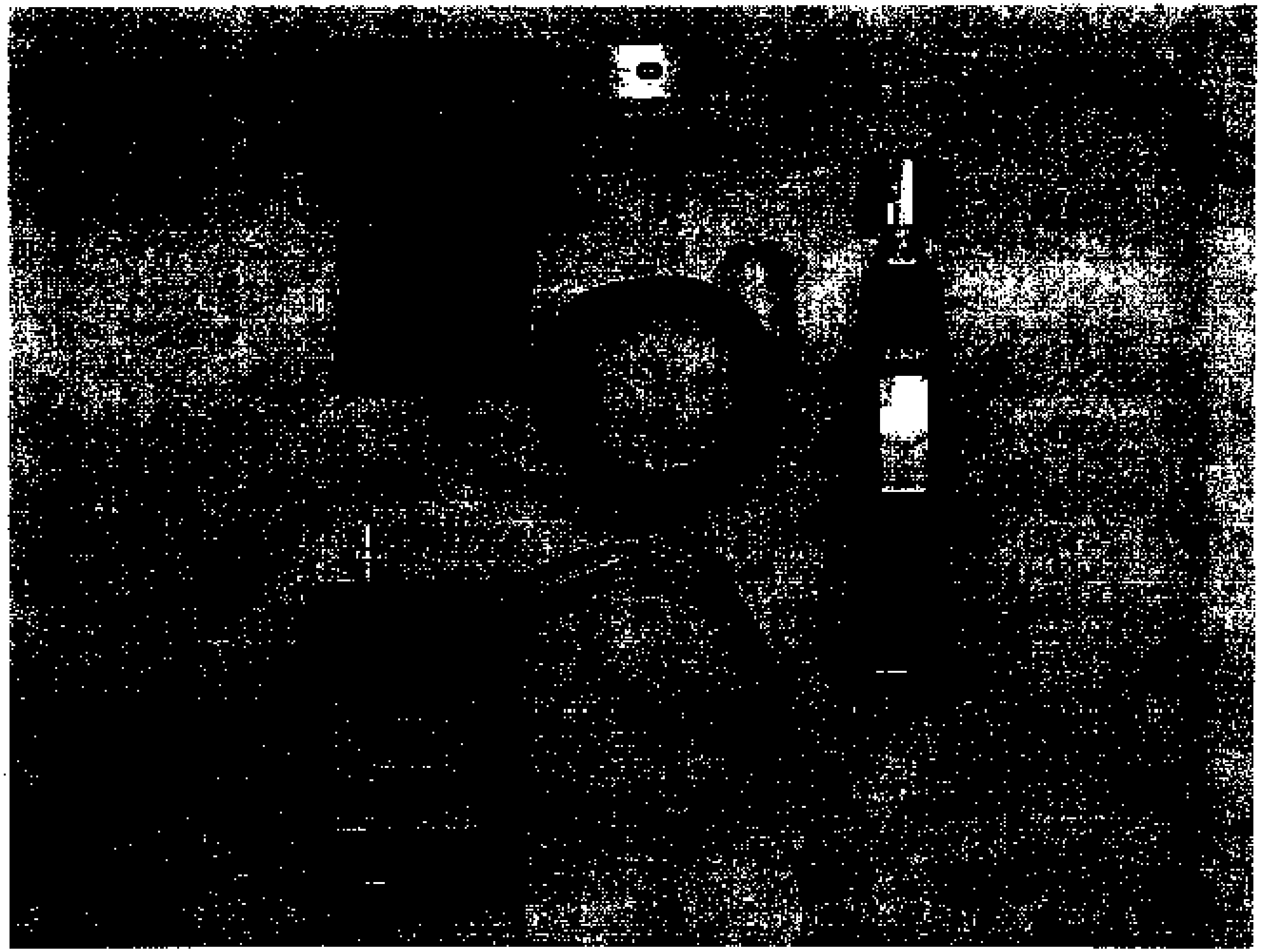
- **Grease Life**
- **Dropping Point**
- **Base Oil Viscosity**
- **Not Fatigue Promoting**
- **Corrosion Protection**
- **Mechanical Stability**
- **Optimum Oil Bleeding**
- **Compatibility with Seal Material**
- **High Temperature Performance**
- **Low Temperature Performance**
- **Anti-Wear Protection**
- **False Brinelling Protection**
- **Water Resistance**
- **Shear Stability**
- **Adhesive Properties**
- **Compatibility with Cage Material**

We invite you to come to SKF's Aiken factory

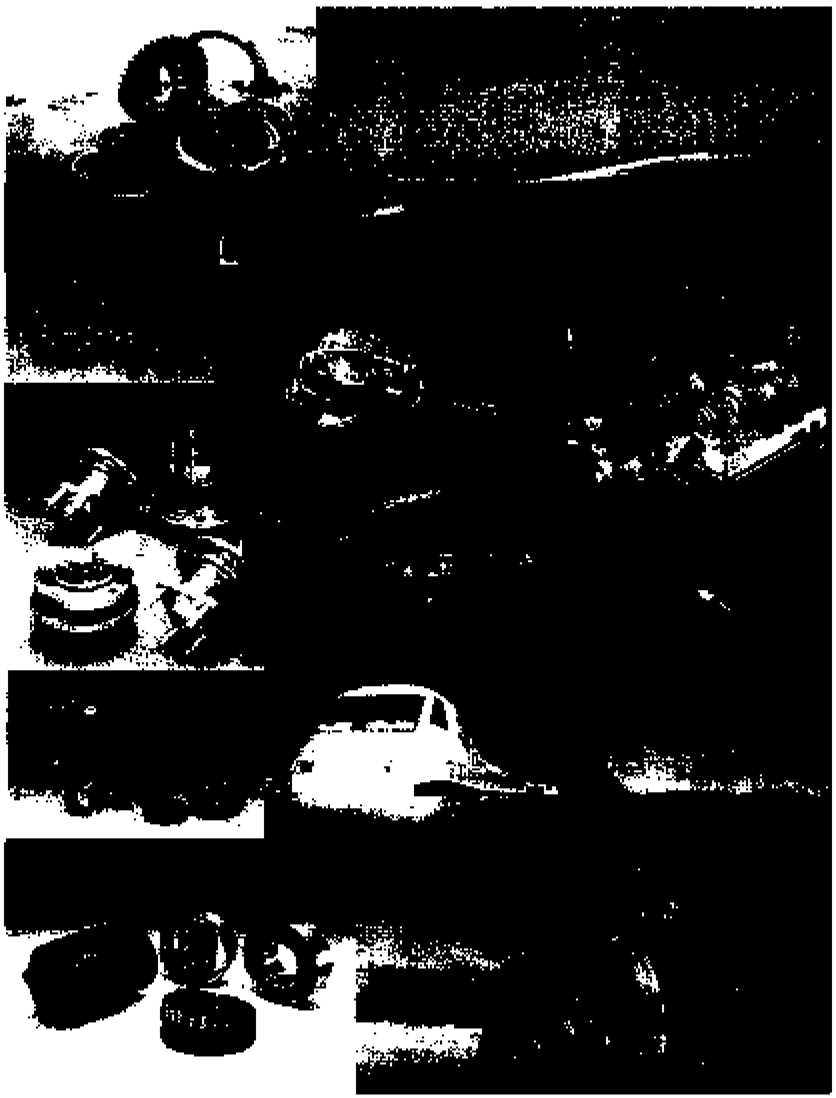


- Fully integrated and balanced manufacturing channel for THU 2 (Full Flange Version)
- Capacity: 300.000 Units/year
- In operation since: 1998
- A-TMU Assembly Channel under preparation
- Controlled Environment

Vibration Monitoring

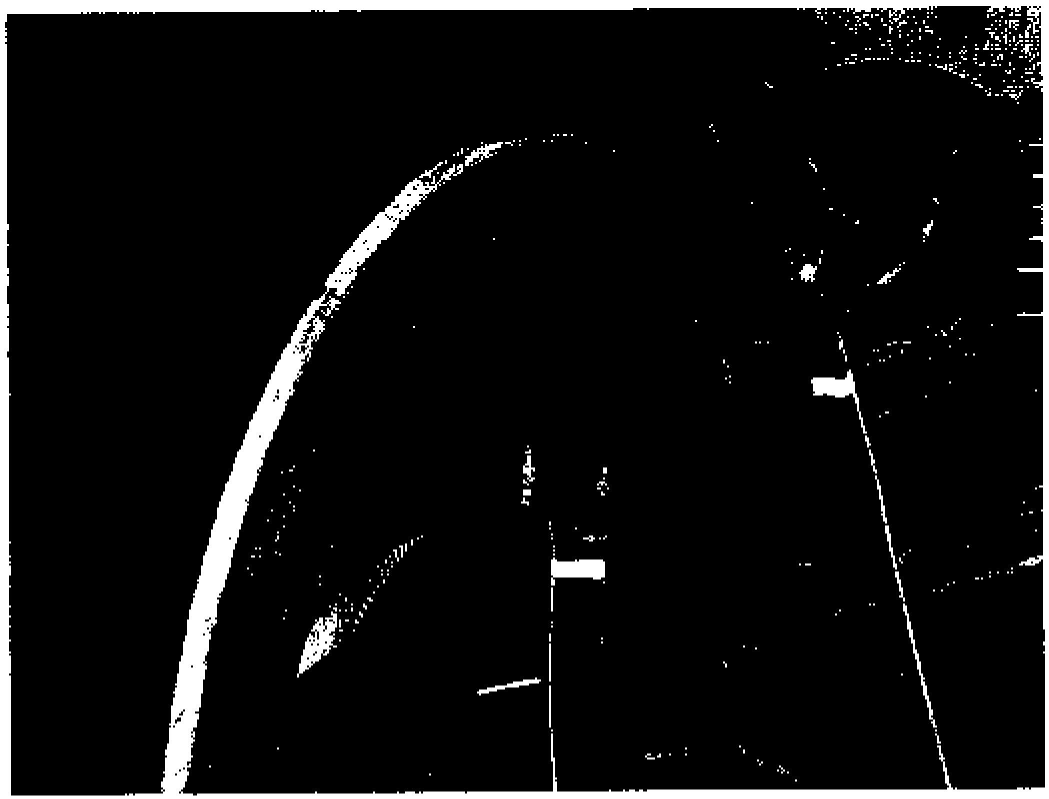


SKF Key Technologies



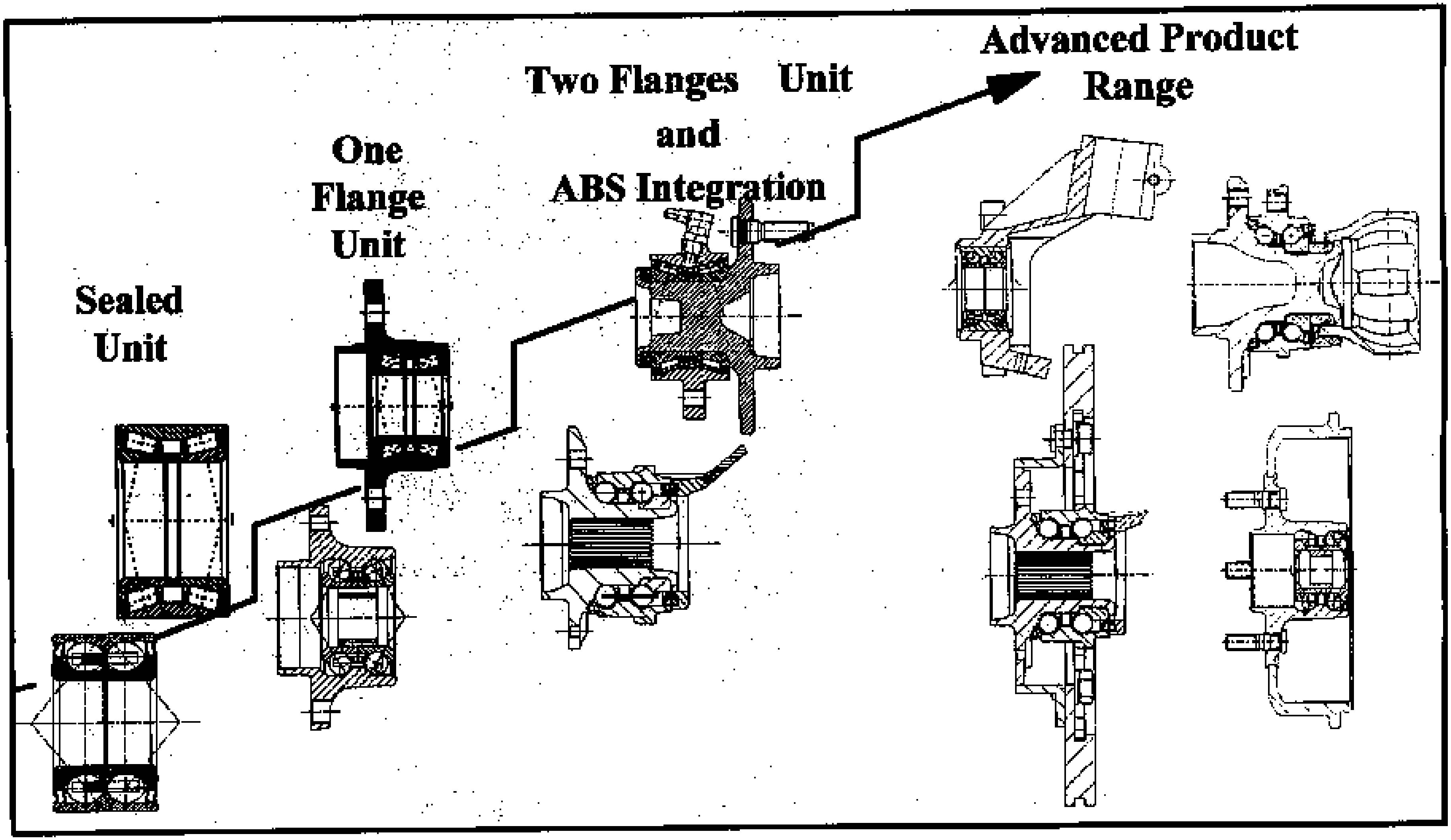
- Materials - steel / ceramics / polymers / elastomers
- Coatings
- Lubrication
- Manufacturing Technologies
- Mechatronics
- **Noise & Vibration / System Dynamics**
- Analytical Modelling
- Experimental Testing

SKF 001605

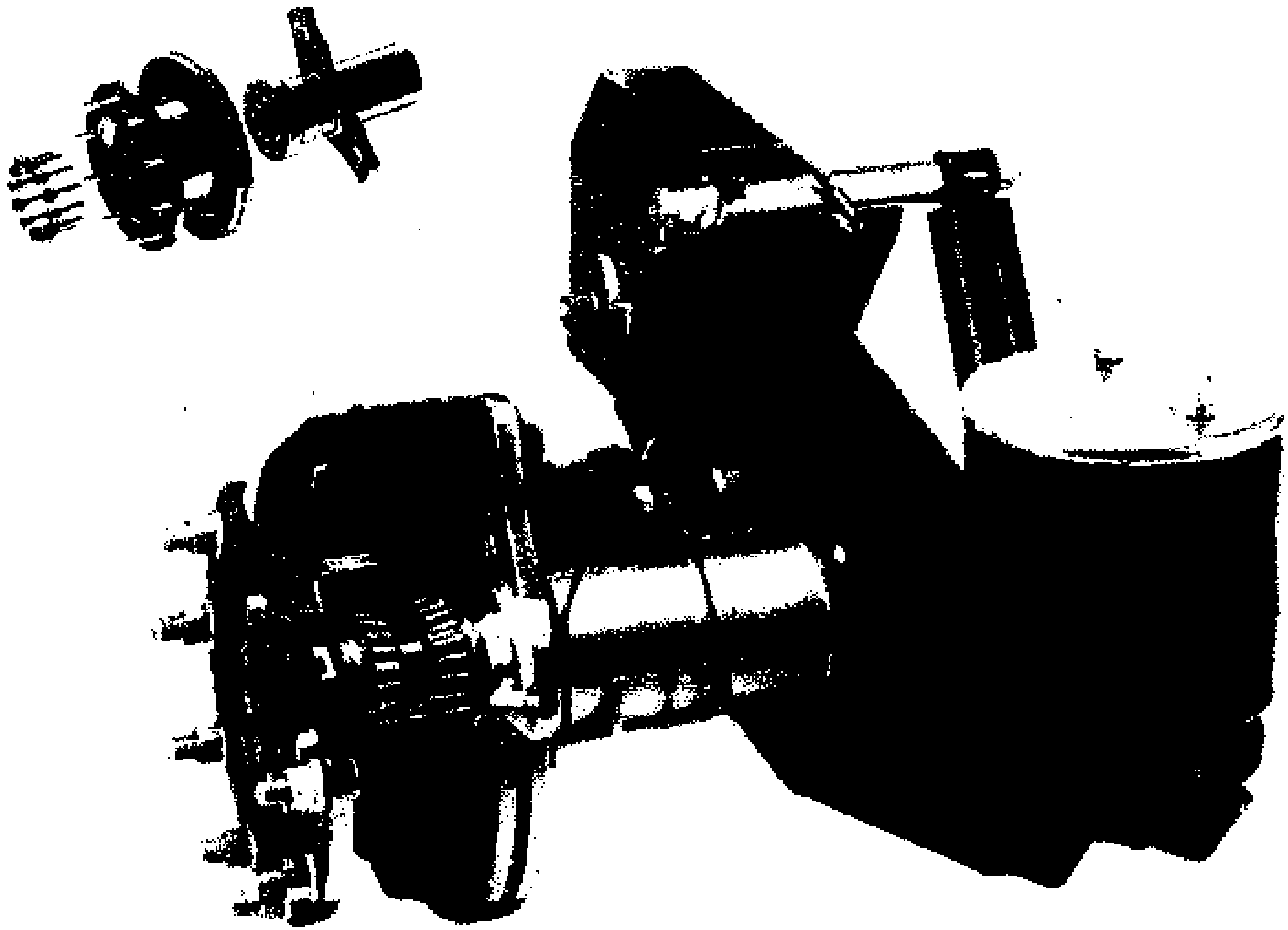


SKF 001606

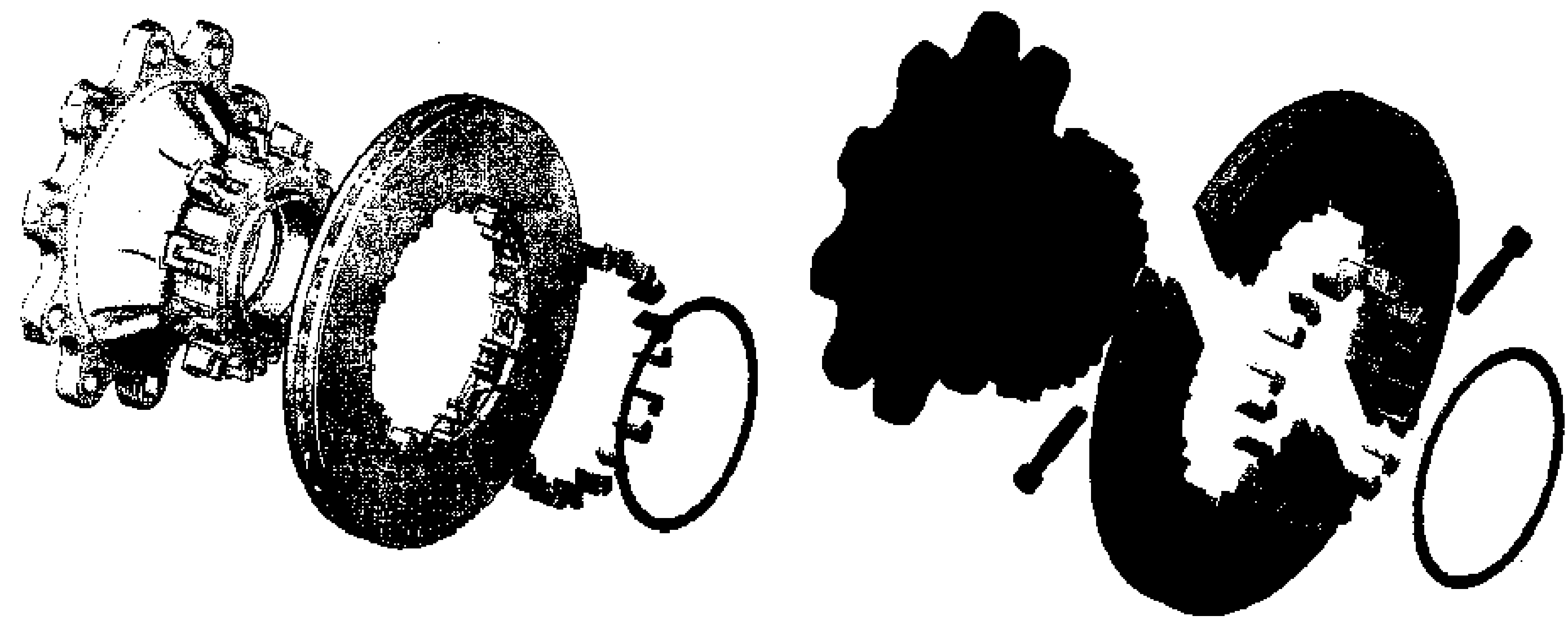
Future Products
Trucks to follow Cars



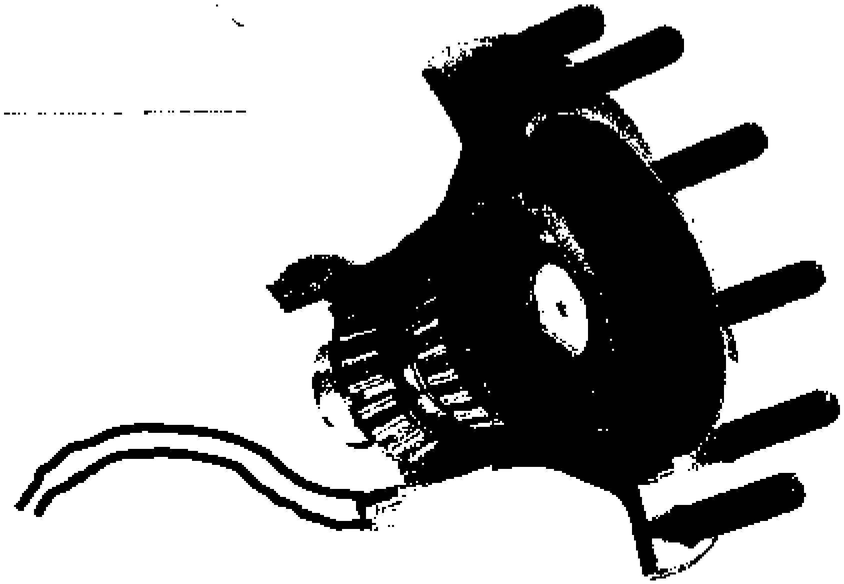
SAF Intradisc Plus



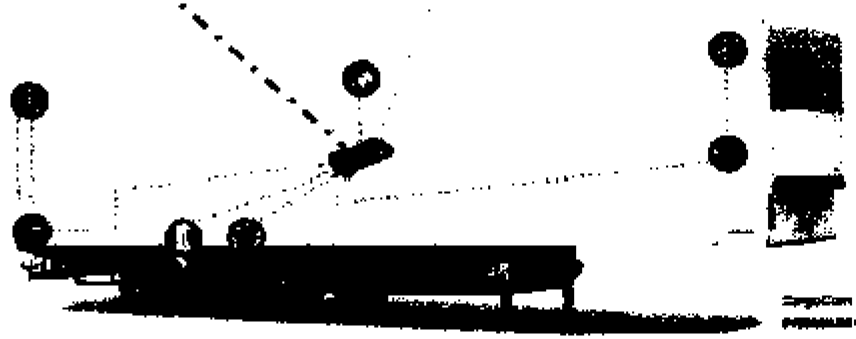
Disk Brake



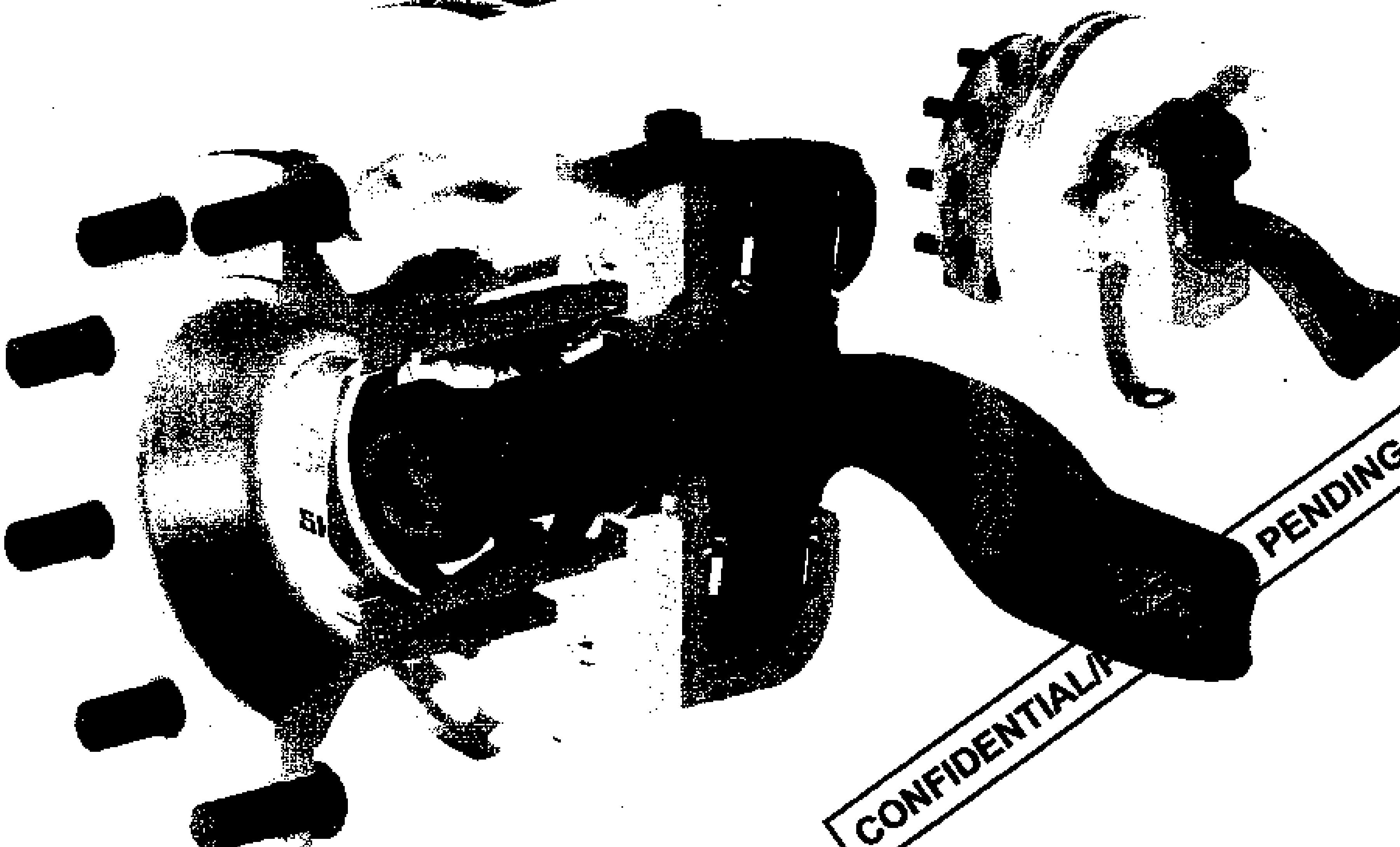
iTHU



Erfassung, Speicherung und Übersendung von Ortungs- und Betriebsdaten

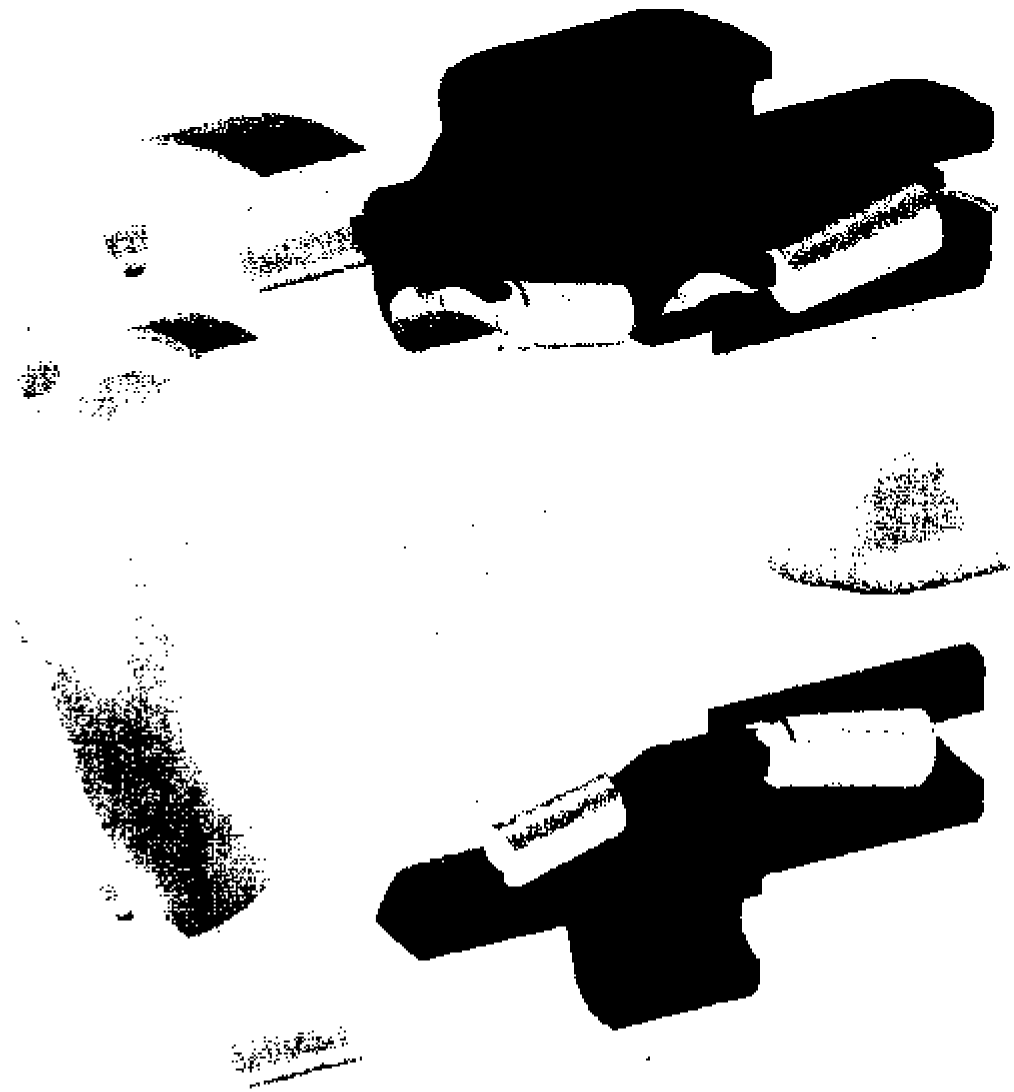


Truck Corner Module



CONFIDENTIAL/[illegible] PENDING

THU3 with turning IR



Presentation Title

Subtitle

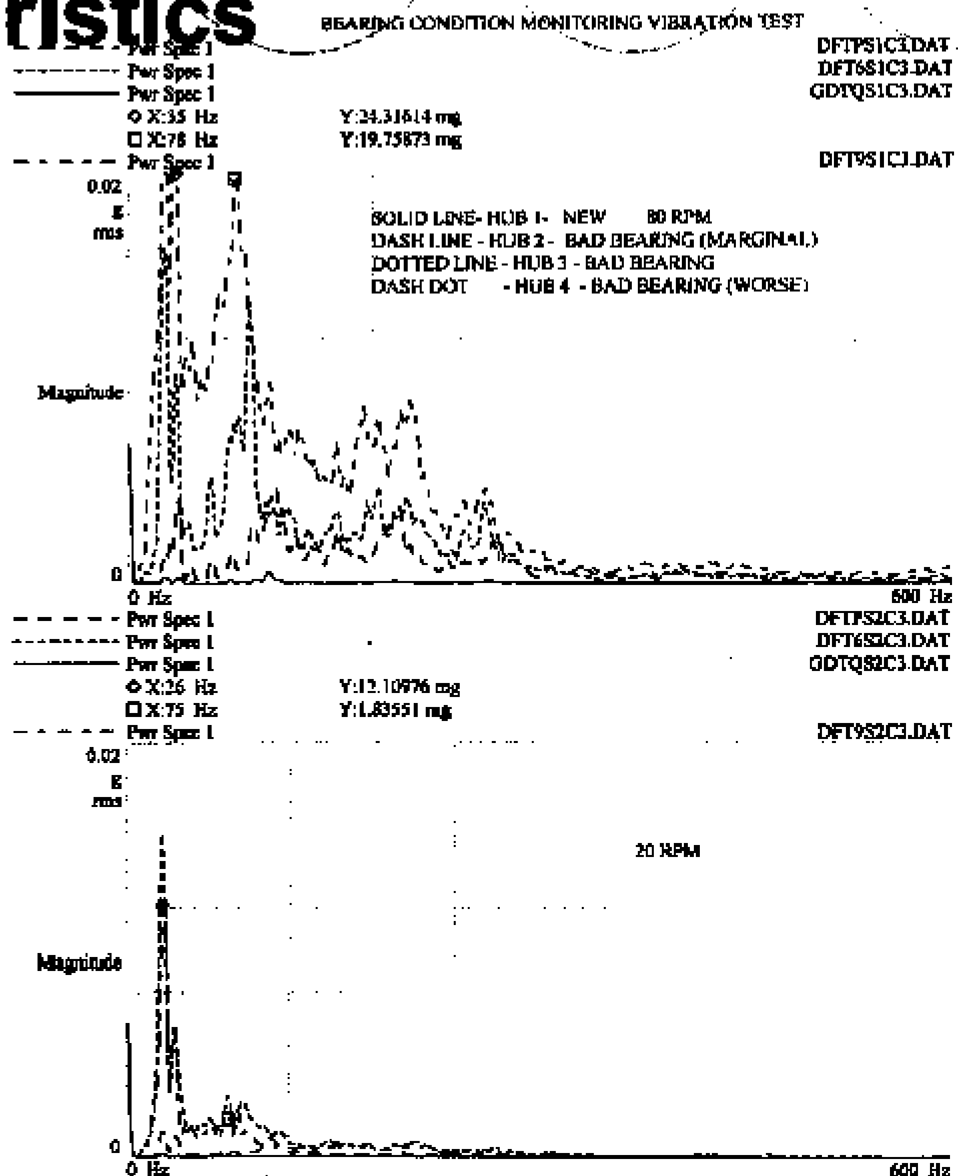
Presentation Date
Presentation Venue

ArvinMeritor

SKF 001613

Vibration Characteristics

- Shows differentiation good unit vs. damaged
  - Most activity in lower frequency ranges
  - Scale of readings is small



COMPARISON OF VIBRATION AT TWO DIFFERENT SPEED AS MEASURED AT THE KINGPIN LOCATION

SKF Vibration Probe

- Industrial unit exists
  - Used today for various industrial bearing monitoring applications
    - Used at operating speeds and loads
- Modifications required:
  - Increased gain
  - Lower electrical noise
  - Remote sampling switch and indicator lights
  - Other minor issues

Inspection Procedure

- Raise wheel ends off the floor (on jack stands).
- Clean kingpin surface
- Mount probe on kingpin surface (magnetic probe)
- Mount assist device
- Rotate tire at 60 to 80 rpm
- Push sampling button
- Record reading (green/red)
  - Return to service or…
  - Replace hub unit

Project Milestones

- Proof of concept
  - Evaluation of all devices
- Field trial evaluation – selection
  - Ryder 7/24 & 25
- Prototype revisions
  - 7/29
  - Mechanical assist device with tachometer
- Field trial – scheduled week of 8/12
  - 5 to 10 Production intent units
    - Instruction sets
    - Any final revisions
- Production release – week of 8/19
- Shipment of first units to field – 9/15

Discussion

Main Topic

Juergen Schultheis/SCHUSKF
07/05 01:58 PM

Subject: **Inner ring hardness (incoming inspection)**

Category: Quality

Overview for inner ring hardness (sub-supplied) operation:

HardnessIR_Aiken.xl

Discussion

Mail[illegible]

Juergen Schuh[illegible]/SCH/SKF
07/[illegible]5 08:13 AM

Subject: Seal fit / assembly process

Category: Quality

Seal fit: seal assembly process

Sealfit_assembly.do

Discussion
Main Topic

Juergen
Schul[illegible]
07/25 08:11 AM

Subject: **Stud incoming inspection ytd. 2002**

Category: Quality

Overview of content of supplier certificates for studs:

studincominginsp ytd02.x

SKF 001626

VB-BTF0052 A STUD LOT NUMBER TRACKING

LOT 1						LOT 5				
MFR. Date	Julian Date	SKF P/N	Meritor P/N	S/N		MFR. Date	Julian Date	SKF P/N	Meritor P/N	S/N
3/12/2001	06201	BTF-0052 A	HFFOUTS 32	334883		10/29/2001	30201	BTF-0052 A	HFFOUTS 32	361374
3/13/2001	06201	BTF-0052 A	HFFOUTS 32	334884		10/29/2001	30201	BTF-0052 A	HFFOUTS 32	361375
3/13/2001	06201	BTF-0052 A	HFFOUTS 32	334885		10/29/2001	30201	BTF-0052 A	HFFOUTS 32	361376
3/13/2001	06201	BTF-0052 A	HFFOUTS 32	334886		10/29/2001	30201	BTF-0052 A	HFFOUTS 32	361377
3/13/2001	06201	BTF-0052 A	HFFOUTS 32	334887		10/29/2001	30201	BTF-0052 A	HFFOUTS 32	361378
LOT 2						LOT 6				
MFR. Date	Julian Date	SKF P/N	Meritor P/N	S/N		MFR. Date	Julian Date	SKF P/N	Meritor P/N	S/N
4/30/2001	12001	BTF-0052 A	HFFOUTS 32	340403		12/11/2001	12101	BTF-0052 A	HFFOUTS 32	366900
4/30/2001	12001	BTF-0052 A	HFFOUTS 32	340404		12/11/2001	12101	BTF-0052 A	HFFOUTS 32	366901
4/30/2001	12001	BTF-0052 A	HFFOUTS 32	340405		12/11/2001	12101	BTF-0052 A	HFFOUTS 32	366902
4/30/2001	12001	BTF-0052 A	HFFOUTS 32	340406		12/11/2001	12101	BTF-0052 A	HFFOUTS 32	366903
4/30/2001	12001	BTF-0052 A	HFFOUTS 32	340407		12/11/2001	12101	BTF-0052 A	HFFOUTS 32	366904
LOT 3						LOT 7				
MFR. Date	Julian Date	SKF P/N	Meritor P/N	S/N		MFR. Date	Julian Date	SKF P/N	Meritor P/N	S/N
7/25/2001	20601	BTF-0052 A	HFFOUTS 32	345863		2/4/2002	03502	BTF-0052 A	HFFOUTS 32	367982
7/25/2001	20601	BTF-0052 A	HFFOUTS 32	345864		2/4/2002	03502	BTF-0052 A	HFFOUTS 32	367983
7/25/2001	20601	BTF-0052 A	HFFOUTS 32	345865		2/4/2002	03502	BTF-0052 A	HFFOUTS 32	367984
7/25/2001	20601	BTF-0052 A	HFFOUTS 32	345866		2/4/2002	03502	BTF-0052 A	HFFOUTS 32	367985
7/25/2001	20601	BTF-0052 A	HFFOUTS 32	345867		2/4/2002	03502	BTF-0052 A	HFFOUTS 32	367986
LOT 4						LOT 8				
MFR. Date	Julian Date	SKF P/N	Meritor P/N	S/N		MFR. Date	Julian Date	SKF P/N	Meritor P/N	S/N
10/2/2001	27501	BTF-0052 A	HFFOUTS 32	361374		3/18/2002	07702	BTF-0052 A	HFFOUTS 32	374168
10/2/2001	27501	BTF-0052 A	HFFOUTS 32	361375		3/18/2002	07702	BTF-0052 A	HFFOUTS 32	374169
10/2/2001	27501	BTF-0052 A	HFFOUTS 32	361376		3/18/2002	07702	BTF-0052 A	HFFOUTS 32	374170
10/2/2001	27501	BTF-0052 A	HFFOUTS 32	361377		3/18/2002	07702	BTF-0052 A	HFFOUTS 32	374171
10/2/2001	27501	BTF-0052 A	HFFOUTS 32	361378		3/18/2002	07702	BTF-0052 A	HFFOUTS 32	374172

Discussion

Main Topic

Juergen Schultheis/SCH/SKF
07/25 07:47 AM

Subject: **Internal geometry - Aiken 98 - 2002**

Category: Quality

Overview on internal geometry data from Aiken from 98 to 2002:

Monthly Internal Geometry Results98-0:

Discussion
Main Topic

Juergen Schultheis/SCH/SKF
07/24 07:47 PM

Subject: **Traceability System (to be implemented)**

Category: Quality

According to the overview of parts used for THU applications traceability system will be implemented:

AIKEN THU MAJOR SUPPLIER TRACE LIST.

Traceability documentation: (to be implemented)

Traceability.doc

SKF 001636

BTF-0042 A / B / AA / BA

Component list	Part No.	Traceability	Frequency	Tracking Process
Cage	CJ-BTF-0030	Manufacturing Date	Each Box	Operator Log entry at Change-over and when Batch Lot No. and or Product Manufacturing Date change
Grease	GREASE EP3 LF	Batch Lot No.	Each Drum	
Inner Ring Forge	JM-BTF-0030	Order & Heat No.	Each Box	
Outer Ring Forge	OF-BTF-0030	Die Code	Each Unit	
Roller	RT-502L	Manufacturing Date	Each Box	
Clip	RR-BTF-0030	Delivery Date	Each Box	
Seal	SR-BTF-0026	Manufacturing Date	Each Box	
SF Seal	SV-BT-20029EA	Manufacturing Date	Each Box	
Stud	VB-BTF-0052A	Batch Lot No.	Each Box	
Stud	VB-BTF-0042B	Batch Lot No.	Each Box	
ABS	VF-BTF-0042	Manufacturing Date	Each Box	

BTF-0065 A & B

Component list	Part No.	Traceability	Frequency	Tracking Process
Cage	CJ-BTF-0031	Manufacturing Date	Each Box	Operator Log entry at Change-over and when Batch Lot No. and or Product Manufacturing Date change
Grease	GREASE GWZ	Batch Lot No.	Each Drum	
Inner Ring Forge	JM-BTF-0025	Order & Heat No.	Each Box	
Outer Ring Forge	OF-BTF-0075	Die Code	Each Unit	
Clip	RR-BTF-0052	Manufacturing Date	Each Box	
Roller	RT-502L	Delivery Date	Each Box	
Seal	SR-BTF-0050	Manufacturing Date	Each Box	
R-Safe Seal	SV-BTFB-446329CD	Manufacturing Date	Each Box	
Stud	VB-BTF-0052A	Batch Lot No.	Each Box	
Stud	VB-BTF-0052B	Batch Lot No.	Each Box	
ABS	VF-BTF-0031	Manufacturing Date	Each Box	

Traceability documentation for BTF 0065

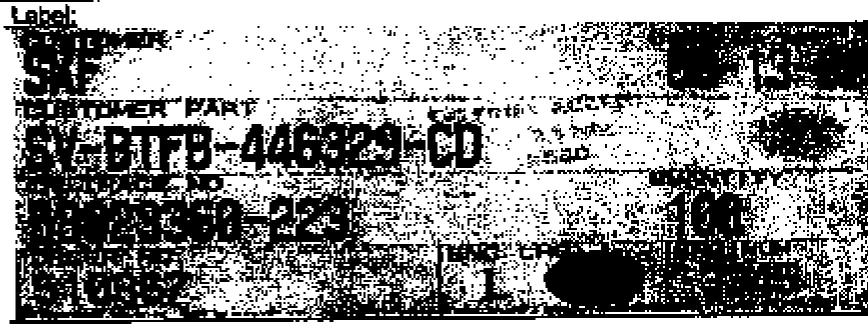
Part designation: **R - Safe Seal**

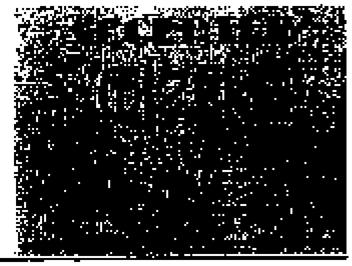
Part number: **SV - BTFB - 446329 CD**

Date:

....

Label:





Julien date:	Batch lot number:	Incoming release date	Remarks:

Traceability documentation for BTF 0065

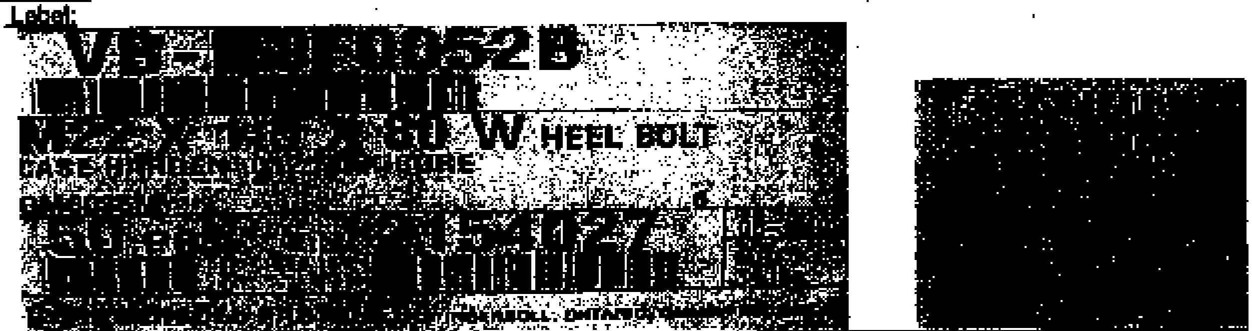
Date:

....

Part designation: **Stud**

Part number: **VB - BTF - 0052 B**

Label:



Julien date:	Batch lot number:	Incoming release date:	Remarks:

Traceability documentation for BTF 0065

Part designation: **ABS ring** Part number: **VF - BTF - 0031**	Date: ....

Label:

Part No. VF-BTF-00
Qty. 144
Weight 358
P.O. No. M12834
Line ~~[illegible]~~ 2
Date 7-2-02

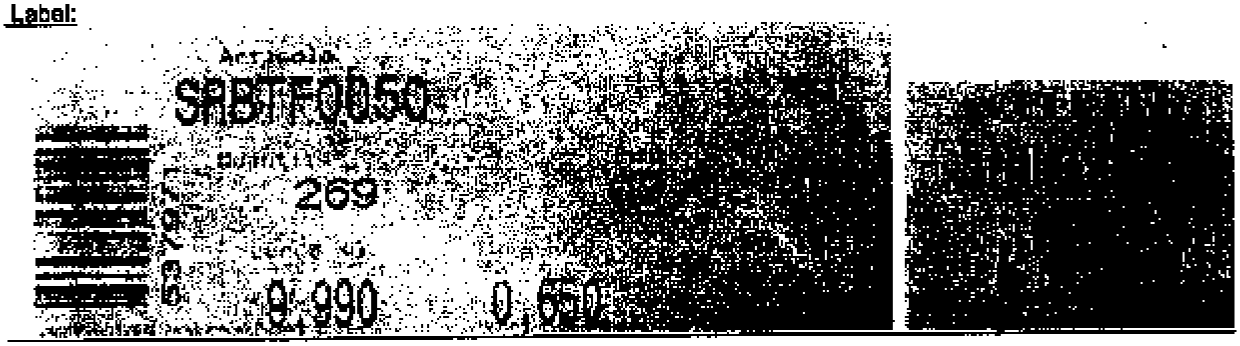
[redacted]

Julien date:	Manufacturing date / number	Incoming release date:	Remarks: Remarks:

SKF 001640

Traceability documentation for BTF 0065	Date:
Part designation: **Seal**	....
Part number: **SR - BTF - 0050**	

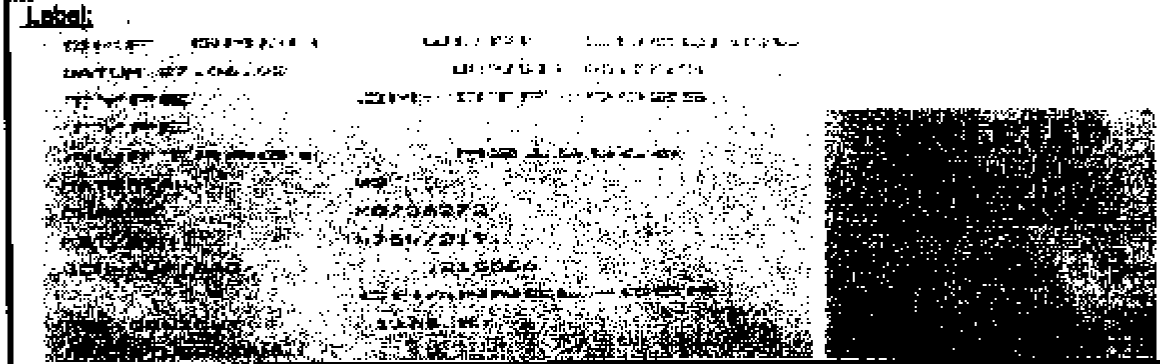
Label:



Julien date:	Manufacturing date:	Incoming release date:	Remarks:

Traceability documentation for BTF 0065 Part designation: **Inner Ring Forge** Part number: **JM-BTF-0025**	Date: ....

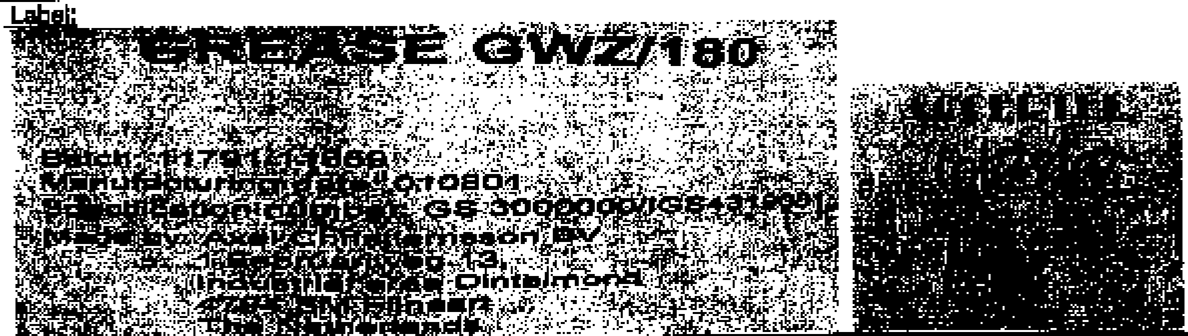
Label:



Julien date:	Referenct to order no. / heat number	Incoming release date:	Remarks:

Traceability documentation for BTF 0065	Date:
Part designation: Grease Part number: Grease GWZ	…………………………………

Label:

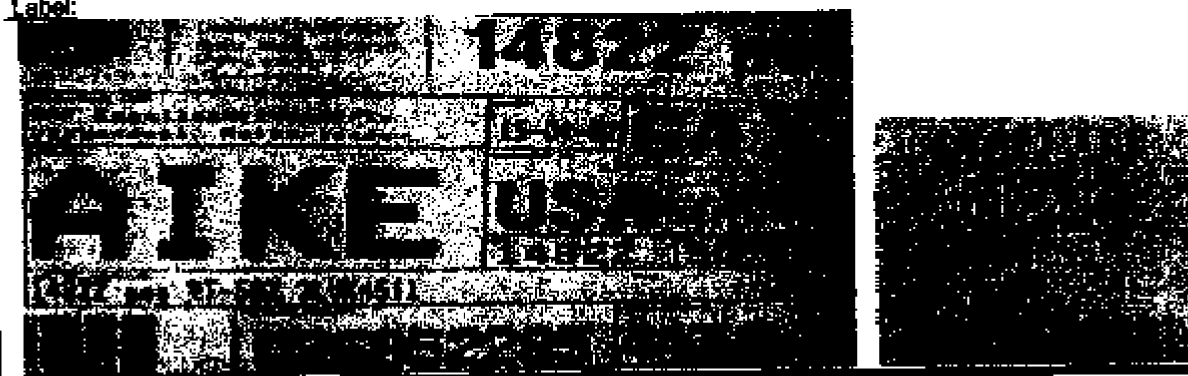


Julien date:	Reference to Batch / Lot No.:	Incoming release date:	Remarks:

SKF 001643

Traceability documentation for BTF 0065 Part designation: **Rollers** Part number: **RT 502L**	Date: ....

Label:



Julien date:	Reference to delivery date:	Incoming release date:	Remarks:

Traceability documentation for BTF 0065

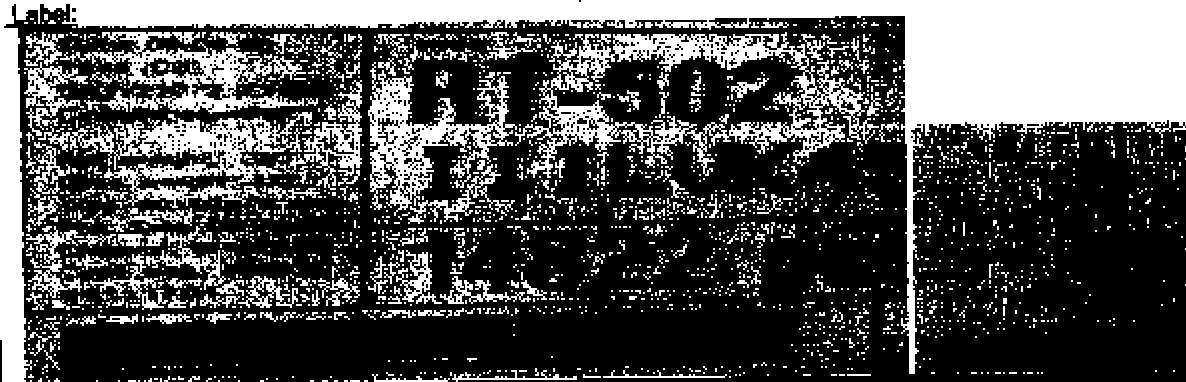
Date:

....

Part designation: **Rollers**

Part number: **RT 502L**

Label:



Julien date:	Reference to assembled part:	Incoming release date:	Remarks:

Traceability documentation for BTF 0065

Date:

Part designation: **Cage**

Part number: **CJ-BTF-0031**

Label:

CENTER
NY
KVILLE
F

SKF LOGISTICS SERVICES CENTER
GERMANY

D010813

GA X

USA

580 | 15 | 05

USA83

CJ-BTF-0031

502398372

36

Julien date:	Reference to assembled part:	Incoming release date:	Remarks:

Traceability documentation for BTF 0065

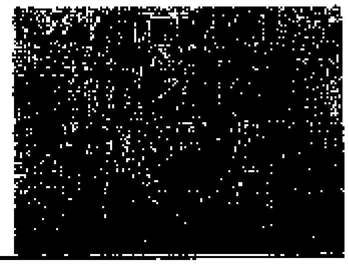
Date:

....

Part designation: **Outer Ring Forge**

Part number: **OF-BTF-0075**

Label:



Julien date:	Reference to Die Code	Incoming release date:	Remarks:

Traceability documentation for BTF 0065 Part designation: .... Part number:	Date: ....

Label:

Julien date:	Reference to assembled part:	Incoming release date:	Remarks:

SKF 001648

Traceability documentation for BTF 0065

Part designation: ....

Part number: ....

Date:

....

Label:

Julien date:	Reference to assembled part:	Incoming release date:	Remarks:

Traceability documentation for BTF 0065

Part designation: ....

Part number: ....

Date:

....

Label:

Julien date:	Reference to assembled part:	Incoming release date:	Remarks:

Discussion

Subject: **Apex point for THU application**

Category: Quality

Apex point definition for THU application:

apex_point.doc

Discussion

[redacted]

Subject: Axial Clearance Procedures

Category: Quality

Comparison of manufacturing the correct axial clearance between SKF Luechow and SKF Aiken

Axialclear_Lue_Aiken.do

Procedure for calibration of axial clearance measuring automatics at Aiken:

axialclear_routine_aiken.dc

Differences in manufacturing / matching the specified axial clearance between SKF Aiken and SKF Luechow:

SKF Aiken:	SKF Luechow:
IR raceway diameter grinding according to defined tolerances	OR raceway diameter grinding according to defined tolerances
Stand out measuring of cone set (2 cones) after assembly of rollers and cages by measuring automatics	100% OR raceway diameter measuring by automatics
Stand out result of cone sett transferred to OR raceway grinder - raceway of OR will specifically ground for the cone set.	cones are grouped in 6 different groups (stand out)
OR and cones set will be matched	According to outer diameter the the adequate cones (stand out) are assembled automaticalty.
100% measuring of axial clearance by measuring automatics	100% measuring of axial clearance by measuring automatics.
According to axial clearance result unit will be sorted as "in specification" or "out of spec." "units in spec" will be transferred to next operation.	According to axial clearance result "in spec." process will continue "out of spec." process will be stopped..
"Units out of spec." will be sorted out on special rework station. Operator has to exchange cones according to actual axial clearance results.	Operator has to exchange the cones manually.
Reworked units have to pass 100% axial clearance measuring automatics again.	Re-matched units will be checked for axial clearance again. Only units "in spec." can leave the station.

Discussion

[illegible]

Subject: Axial Clearance exceeded (Monson case)

Category: Quality

Attached report from Chris Jones regarding exceeded Axial Clearance:

SKF 001656

doc0.tif

Additional Interim Corrective Actions:

1. Requested Edmunds Gage for complete on site evaluation of axial clearance gage for re-design of gage to eliminate issue.

2. Replace diaphragm every three months to ensure no material failure occurred, while complete gage design was being investigated.

3. Create two hub assemblies to be used as masters and verify the on-line gage repeatability on a regular basis.

Corrective Actions:

1. Redesign gage and fabricate parts by Edmunds Gage.
   Completion Date: February 2000.
2. Retrofit gage with new special cylinder.
   Completion Date: March 2000.
3. Implement three masters to perform validation checks at the beginning of each shift and chart results on form SKF THU-0034.

SKF

Automotive Division
Aiken, South Carolina
Truck Hub Unit 2.1

Axial Clearance Results

Month: ______________ Part Number: ______________

Master	DAY 1		DAY 2		DAY 3		DAY 4		DAY 5		DAY 6		DAY 7		DAY 8	
	Result	Initials	Result	Initials	Result	Initials	Result	Initials	Result	Initials	Result	Initials	Result	Initials	Result	Initials
BG35922-1																
BG35922-2																
BG35922-3																

Master	DAY 9		DAY 10		DAY 11		DAY 12		DAY 13		DAY 14		DAY 15		DAY 16	
	Result	Initials	Result	Initials	Result	Initials	Result	Initials	Result	Initials	Result	Initials	Result	Initials	Result	Initials
BG35922-1																
BG35922-2																
BG35922-3																

Master	DAY 17		DAY 18		DAY 19		DAY 20		DAY 21		DAY 22		DAY 23		DAY 24	
	Result	Initials	Result	Initials	Result	Initials	Result	Initials	Result	Initials	Result	Initials	Result	Initials	Result	Initials
BG35922-1																
BG35922-2																
BG35922-3																

Master	DAY 25		DAY 26		DAY 27		DAY 28		DAY 29		DAY 30		DAY 31	
	Result	Initials	Result	Initials	Result	Initials	Result	Initials	Result	Initials	Result	Initials	Result	Initials
BG35922-1														
BG35922-2														
BG35922-3														

BG35922-1 Range = .005 - .009 mm BG35922-2 Range = .040 - .045 mm 922-3 Range = .070 - .075 mm

Form SKF THU-0034
The actions above have provided a consistent application of the 300 Newton load.

Current Containment Actions:

A stock audit was performed on September 20, 2001, in which five bearings from each month remaining in the warehouse (March, April, May, July, & August of 2001) were re-inspected for axial clearance. The studs, ABS rings were removed and the axial clearance was rechecked using the on-line axial clearance gage. The results were compared to the initial readings stored in the GE Fanuc Cimplicity during their original production. Remembering that these bearings were rechecked with grease and seals installed whereas the original measurements did not have these impediments, our findings indicate the rechecked results are similar to the initial measurements.

Discussion
Main Topic

Juergen Schultheis/SCHSKF
07/19 02:27 AM

Subject: Summary of deviation approvals (Thread and Hub Cap)

Category: Quality

Attached summary of approved deviation requests concerning:
- Hub Cap
- Thread of THU Unit

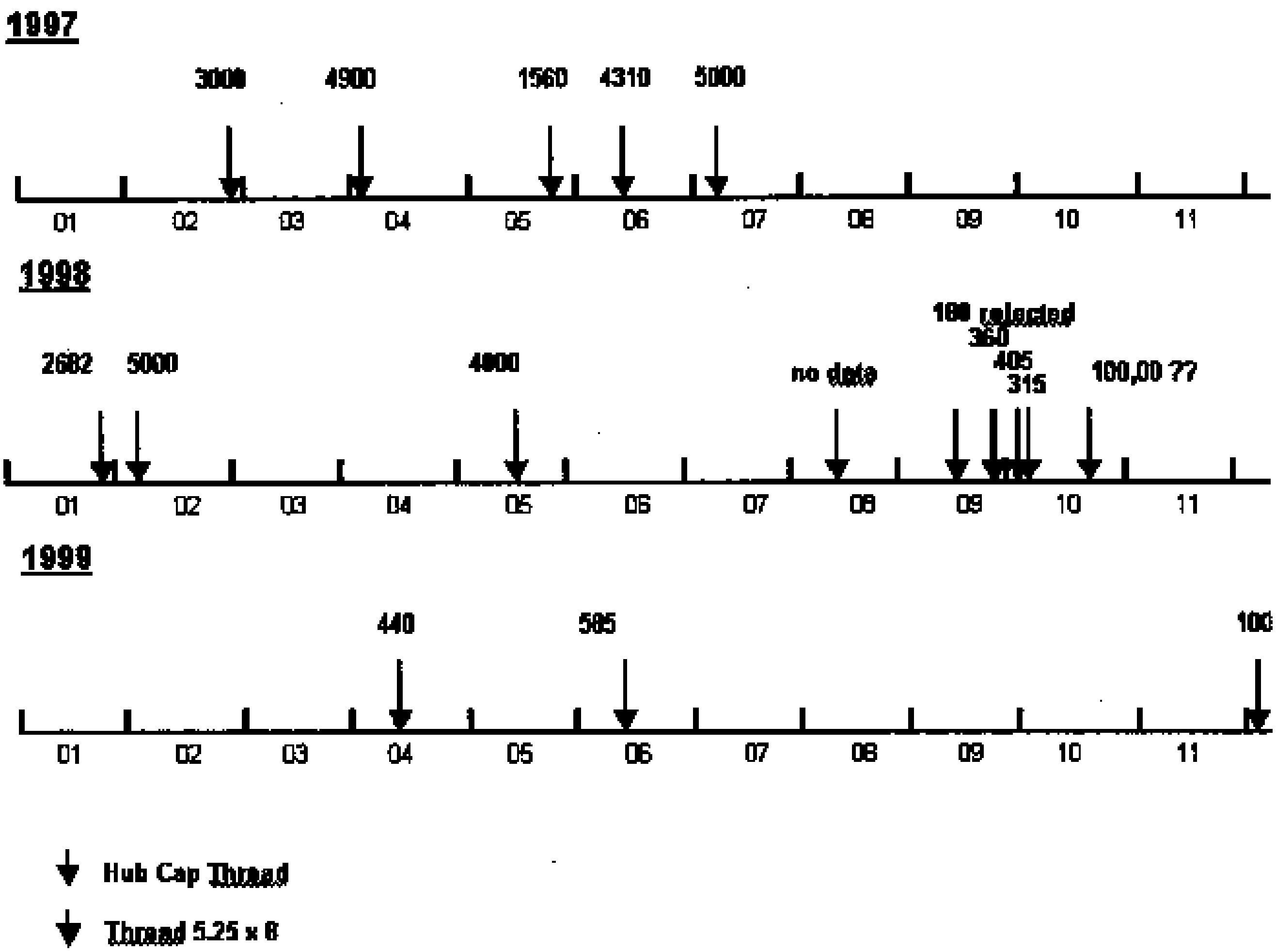
HubCapDev.xls

Graph for approved deviation requests:

hubcapdev_graph.pp

SKF 001664

Summary of Engineering Deviation Requests



schultheis2002-07-19_134325.j schultheis2002-07-19_133826.j schultheis2002-07-19_133842.j

schultheis2002-07-19_133902.j schultheis2002-07-19_133922.j schultheis2002-07-19_133942.j

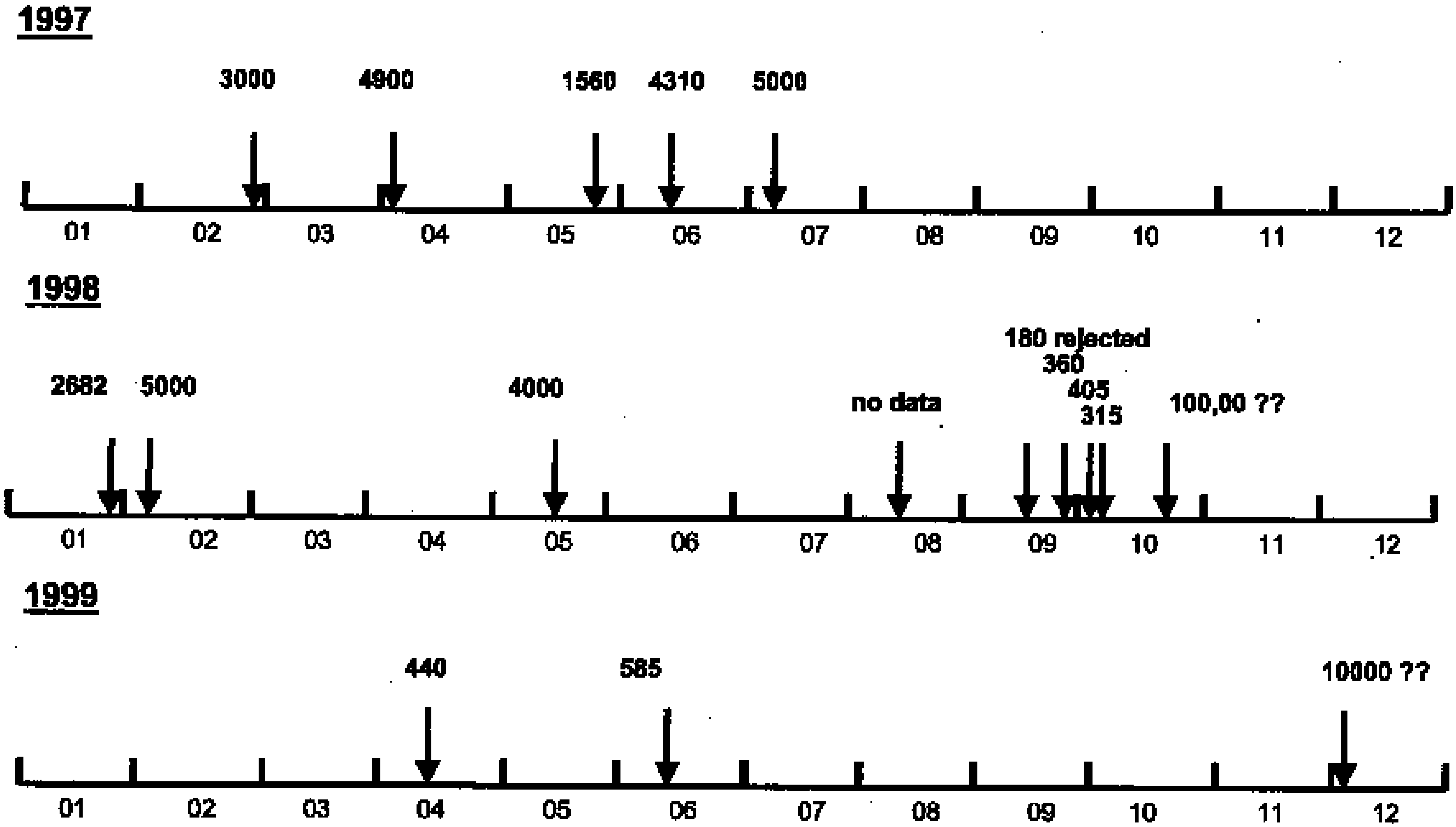
schultheis2002-07-19_134002.j schultheis2002-07-19_134022.j schultheis2002-07-19_134043.j

schultheis2002-07-19_134103.j schultheis2002-07-19_134123.j schultheis2002-07-19_134143.j

schultheis2002-07-19_134203.j schultheis2002-07-19_134224.j schultheis2002-07-19_134244.j schultheis2002-07-19_134304.j schultheis2002-07-19_133753.j

ATQ/J.S/19-07-2002

Summary of Engineering Deviation Requests



Hub Cap Thread

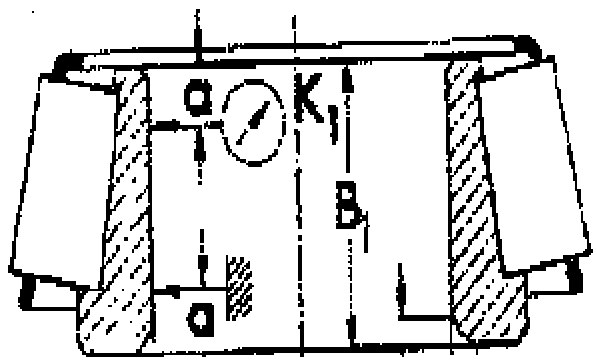
Thread 5.25 x 8

SKF 001671

Discussion	**Subject:**	Capability bore grinding - parameter K1 (rectangularity side face bore)
Main Topic:	**Category:**	Quality
Juergen Schultheis/SCH/SKF 07/18 06:01 AM		

Short term capability investigation for parameter K1:

Measuring principle:



Result:
(Extract from evaluation report)

	CPK	% scrap
99,73%	2,68	0,00
99,865%	2,42	0,00

Sample size 6
N° Samples 50

Average range 2,9
Average 4,94
Sy 0,2258
Avgy 1,6727
99,73 Perc. 0,0598
99,865 Perc. 0,6102

capability_K1.123

Result also verified by capability calculation according to evaluation principle Q-stat.
(authorized evaluation modell from FORD)

Discussion
Main Topic

Juergen Schultheis/SCH/SKF
07/17 04:34 AM

Subject: Roller quality production Glasgow

Category: Quality

Summary about inspection results for roller production at supplier Glasgow.

rollerqual_glasgow.xl

Single audit results:

roller_glas_qresults.jp

SKF 001674

Summary of audit results : Roller production Glasgow (RT-502 III D / B 225)

ATO/ J.S / 16.07.2002

Production date		Parameters Rollers									
		End Radius	End Finish	End Runout	End Waviness	OD Waviness	OD Taper	OD Size	OD Finish	Crown Height	Crown Location
	Sample size	3	2	2	3	3	3	3	2	1	1
	No. of samples										
12/18/1998	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
12/19/1998	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
12/21/1998	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
1/14/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
2/18/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
2/24/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
2/24/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
3/19/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
3/23/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
3/25/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
4/15/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
4/21/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
4/22/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
5/24/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
5/25/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
5/26/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
6/3/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
6/4/1999	3	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
6/4/1999	3	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
6/7/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
6/7/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
7/1/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
7/21/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
7/22/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
8/6/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
8/11/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
8/18/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
9/22/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
9/24/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
9/30/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
10/15/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
10/20/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
11/30/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
12/11/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
12/15/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
12/23/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k

Summary of audit results : Roller production Glasgow (RT-502 III D / B 225)											ATO/ J.S / 18.07.2002
		Parameters									
Production date		End Radius	End Finish	End Runout	End Waviness	OD Waviness	OD Taper	OD Size	OD Finish	Crown Height	Crown Location
	Sample size	3	2	2	3	3	3	3	2	1	1
	No. of samples										
12/16/1998	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
12/19/1998	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
12/21/1998	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
1/14/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
2/16/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
2/24/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
2/24/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
3/19/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
3/23/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
3/25/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
4/15/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
4/21/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
4/22/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
5/24/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
5/25/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
5/28/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
6/3/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
6/4/1999	3	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
6/4/1999	3	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
6/7/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
6/7/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
7/1/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
7/21/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
7/22/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
8/6/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
8/11/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
8/18/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
9/22/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
9/24/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
9/30/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
10/15/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
10/20/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
11/30/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
12/11/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
12/15/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
12/23/1999	4	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k	o.k
Sum samples:	142										
Sample size:		3	2	2	3	3	3	3	2	1	1
Total sampling:		426	284	284	426	426	426	426	284	142	142

Discussion

Main Topic

Juergen Schultheis/SCN/SKF
07/16 11:56

Subject: **Production data for forging JM BTF 0025 (1998 - 2000) Luechow /Material certificates**

Category: Quality

Production data for BTF 0025 from forging unit Luechow and related material certificates and approvals doc0.tif

Produktionsübersicht Schmiede JM-BTF 0025

DATUM	AUFTRAG	Type I	Artikelnummer	Maschine	Kostenstelle I	CHARGE_1	CHARGE_2	CHARGE_3	STCK
14.06.1998	519984	JM-BTF-0025	286050	AMP 70-1	4157	H-P3056	H-P3009		22.320
26.06.1998	528794	JM-BTF-0025	286050	AMP 70-L	4158	H-P3543	H-P3540		23.380
18.08.1998	542404	JM-BTF-0025	286050	AMP 70-L	4158	H-P3543			10.580
08.09.1998	557805	JM-BTF-0025	286050	AMP 70-1	4157	Z136198			18.000
24.09.1998	566230	JM-BTF-0025	286050	AMP 70-1	4157	Z136194			17.280
03.11.1998	590423	JM-BTF-0025	286050	AMP 70-1	4157	KG716960	H-P4401	H-P4724	27.720
12.12.1998	607333	JM-BTF-0025	286050	AMP 70-1	4157	KG718293	KG719020		40.870
18.01.1999	629715	JM-BTF-0025	286050	AMP 70-1	4157	KG719062			18.120
12.02.1999	637228	JM-BTF-0025	286050	AMP 70-L	4158	H-P5935	H-P5963		36.700
24.02.1999	646205	JM-BTF-0025	286050	AMP 70-1	4157	H-P5256	H-P6019		40.590
29.03.1999	660186	JM-BTF-0025	286050	AMP 70-1	4157	Z139666			38.100
25.05.1999	677672	JM-BTF-0025	286050	AMP 70-1	4157	H-P6639	H-P7290		40.320
12.08.1999	721672	JM-BTF-0025	286050	AMP 70-1	4157	KG721639			41.790
17.01.2000	809009	JM-BTF-0025	286050	AMP 70-1	4157	H-P9641			12.210
18.02.2000	826308	JM-BTF-0025	286050	AMP 70-1	4157	H-K1738	H-K1780	H-K1738	39.810
30.03.2000	840661	JM-BTF-0025	286050	AMP 70-1	4157	KG724910			24.430
17.04.2000	851168	JM-BTF-0025	286050	AMP 70-1	4157	KG725665	KG725230		38.140
03.05.2000	858451	JM-BTF-0025	286050	AMP 70-1	4157	KG725658	KG724910	KG726123	38.280
22.06.2000	887015	JM-BTF-0025	286050	AMP 70-1	4157	KG726889			24.640
14.07.2000	898530	JM-BTF-0025	286050	AMP 70-1	4157	KG727528			24.560
11.08.2000	901057	JM-BTF-0025	286050	AMP 70-1	4157	KG727585			38.770

[redacted]

SKF 001680

Datum: 09.07.00
Name: K. Zufp

Discussion

Main Topic

Juergen Schultheis/SCHWEIF
07/16 11:51 AM

Subject: Process Layout Aiken / 100% Measuring Automatics

Category: Quality

Process Flow Chart Aiken

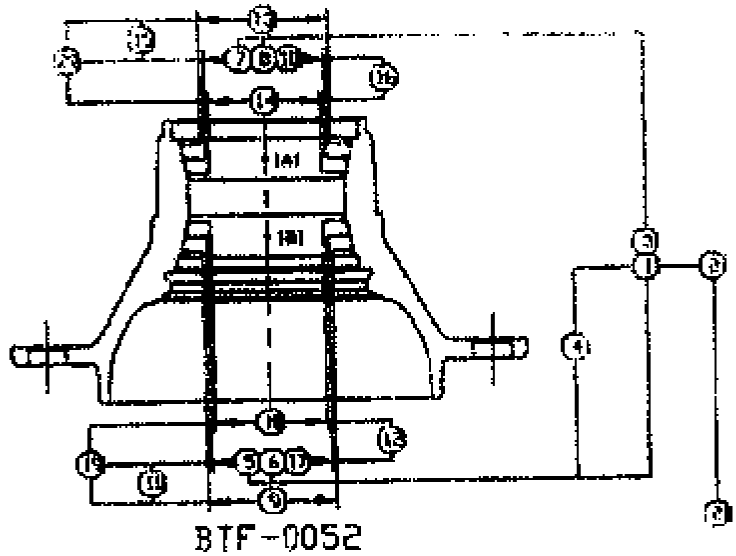
THU_ Process Layout Aiken .>

Measuring principles: 100% measuring automatics grinding / assembly oprations

MPR_100%_summary.dc

Parameters measured 100% by measuring automatics

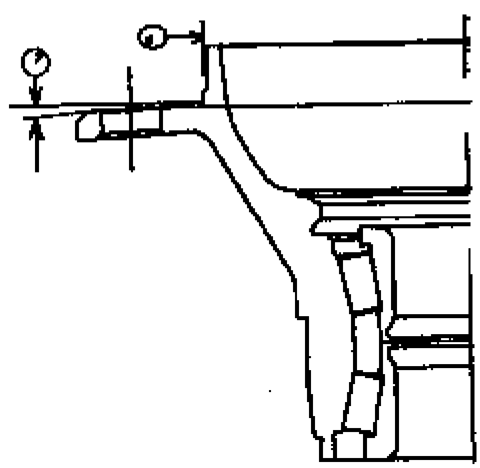
Measuring principles: Edmunds Gage OR grinding



Parameters measured 100% by Edmunds Gage:

Raceway diameter A1 in 3 different levels
- calculation of raceway crowning
- calculation of raceway angle
- calculation of roundness

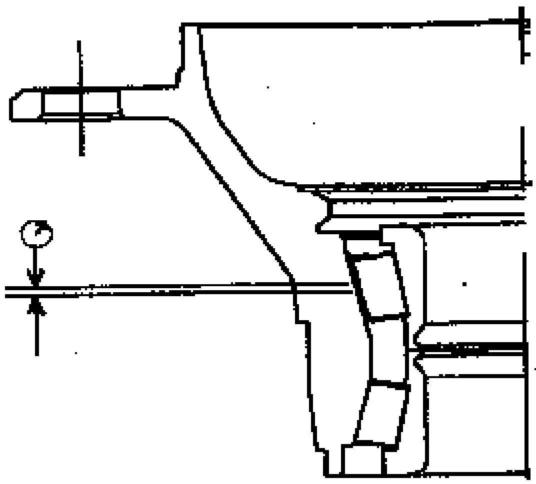
Raceway diameter B1 in 3 different levels
- calculation of raceway crowning
- calculation of raceway angle
- calculation of roundness



Parameters measured 100% by Edmunds Gage:

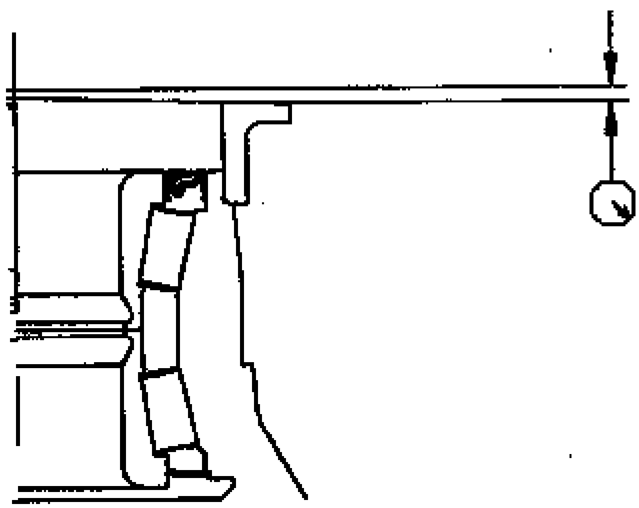
Radial run out - brake pilot (fitting diameter for brake drum)
Axial run out - of flange

Parameters measured 100% by measuring automatics



Parameters measured 100% by Edmunds Gage:

Axial clearance

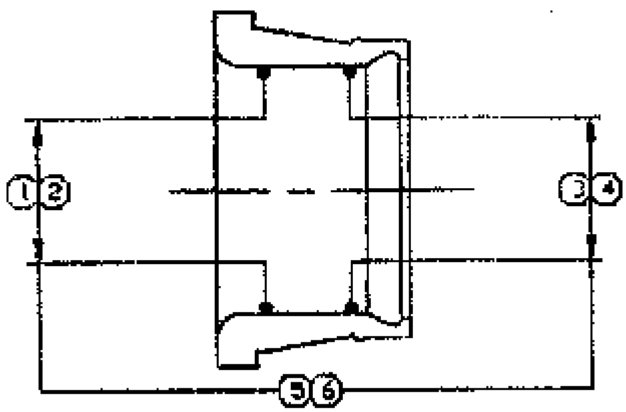


Parameters measured 100% by Edmunds Gage:

ABS run out

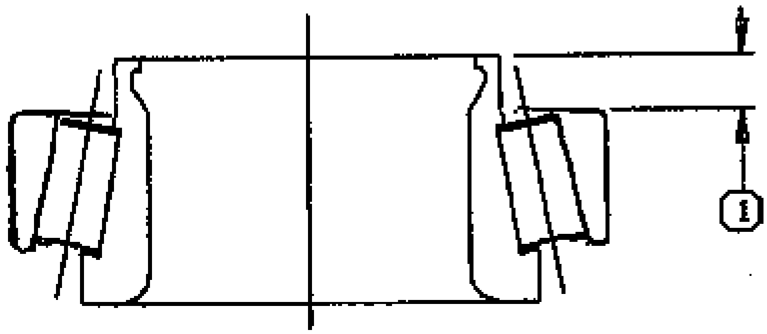
Parameters measured 100% by measuring automatics

Measuring principles: Edmunds Gage IR grinding



Parameters measured 100% by Edmunds Gage:

Bore diameter in 2 different levels
- calculation of conicity



Parameters measured 100% by Edmunds Gage:

Stand out cone

Discussion

Main Topic

Juergen Schultheis/SCH/SKF
07/16 11:21 AM

Subject: Number of replacement studs (status: 22-07-2002)

Category: Quality

The following chart provides delivery dates for the VB-BTF-0052A studs.
They were all shipped to the same customer (ArvinMeritor - Florence).

Date Shipped	Quatity
9/22/99	1,000
2/14/00	1,020
2/8/00	1,037
3/18/00	300
3/15/00	960
4/27/00	300
6/23/00	1,020
7/27/00	720
8/22/00	300
9/15/00	1,020
10/18/00	1,020
11/16/00	1,020
12/27/00	1,020
1/19/01	666
4/19/01	45
4/18/01	2,620
9/18/01	880
11/28/01	30
3/8/02	990
3/23/02	1,035

Bob,
Brad Begley gave me the following data for sale of studs thru Florence:

Long stud
1999--3,361
2000--7,619
2001--5,760
2002--6,698 (YTD thru 7/18/02)

Short stud
1999--70
2000--1,899
2001--3,034
2002--1,360 (YTD thru 7/18/02)

These are sold predominantly to OEMs for sale thru Dealerships.

The increasing sales rate (at least for the long stud) could well indicate a higher failure rate and subsequent stud replacement rate. That's all we can tell you.

Tom Sanko

Discussion

Main Topic

Juergen Schultheis/SCH/SKF
07/[illegible] 11:01 AM

Subject: **Stud investigation summary**

Category: Quality

Investigation results of samples / Certificate results Ingersol

Stud_invest_summary.x

SKF 001721

Discussion
Main Topic

Juergen Schulthels/SCH/SKF
07/16 10:49 AM

Subject: Capability of matching unit in Aiken due to axial clearance

Category: Quality

BTF-0065 AXIAL GAGE REJECT ANALYSIS

Day	Total Parts Produced	No. Of First Time Rejects	First Time Reject Percentage	
10.07.2002	271	18	6,64%	
11.07.2002	290	27	9,31%	
12.07.2002	234	16	6,84%	
Sum	795	61	7,67%	
Average	265	20	7,67%	

Max. Rejected Axle Clearance Value	Min. Rejected Axle Clearance Value
0,090	0,006

Detailed data attached:

axialcap_aiken.xls

SKF 001725

BTF-0065 AXIAL GAGE REJECT ANALYSIS

Day	Total Parts Produced	No. Of First Time Rejects	First Time Reject Percentage
7/10/2002	271	18	6.64%
7/11/2002	290	27	9.31%
7/12/2002	234	16	6.84%
Sum	795	61	7.67%
Average	265	20	7.67%

	Manual Match Inner Ring Cone Sizes				
	20	10	0	-10	-20
Avg. Deviation Resulting From Manual Match	0.035	0.041	0.016	0.020	0.040

Max. Rejected Axle Clearance Value	Min. Rejected Axle Clearance Value
0.098	0.006

Discussion Main Topic	Subject:	Scrap analyses CR-Bethlehem - Visit J. Kirch / J. Schultheis
Juergen Schultheis/SCH/SKF 07/16 10:39 AM	Category:	Quality

CR_Beth_criticaldefects_batch.:

SKF 001732

Scrap rates: Overview per order

Order-no.: 000203

Production dates:	Feb/Mar 00
Batch numbers:	1
Pieces molded:	18,695
Assembled	17,639
Scrap number (total figures)	1,204
Scrap %:	6.4
Good parts	16,439

Scrap Figures: Critical Parameters for application:

Parameters	100%	Q-Insp	Sum	%
Splits	[illegible]	3	[illegible]	[illegible]
ID Nonfills	[illegible]	6	[illegible]	[illegible]
Axial lip nonf.	[illegible]	0	[illegible]	-
OD nonfill	[illegible]	10	10	[illegible]
Torn axial lip	[illegible]	0	0	-
Torn ID	[illegible]	[illegible]	[illegible]	[illegible]

no figures av.

Order-no.: 000203	Machine 10 / French Oil	
	Rubber batches	Product. dates
	41659	02.03 - 08.03.00
	41658	24.02 - 28.02.00
	12985	23.02 - 24.02.00
	41658	27.02 - 02.03.00
	41658	26.02 - 26.02.00

Order-no.: 727583

Production dates:	April/May 00
Batch numbers:	2
Pieces molded:	27,923
Assembled	24,330
Scrap number (total figures)	3,321
Scrap %:	11.9
Good parts	24,602

Scrap Figures: Critical Parameters for application:

Parameters	100%	Q-Insp	Sum	%
Splits	1,931	122	2,053	7.35
ID Nonfills	[illegible]	[illegible]	419	1.50
Axial lip nonf.	[illegible]	[illegible]		-
OD nonfill	638	13	651	2.33
Torn axial lip	0	0		-
Torn ID	22	10	32	0.11

Order-no.: 727583	Machine 16 / French Oil	
	Rubber batches	Product. dates
	41660	27.04 - 28.04.00
	41659	28.04 - 30.04.00
	43934	18.05 - 18.05.00
	43369	11.05 - 16.05.00
	43369	04.05. - 08.05.00
	43939	16.05 - 18.05.00
	41660	01.05 - 04.05.00
	42370	08.05. - 11.05.00
	43939	16.05 - 18.05.00

Order-no.: 727588

Production dates:	Aug 00/ Dec 00 / Jan 01
Batch numbers:	3
Pieces molded:	17,355
Assembled	16,256
Scrap number (total figures)	2,638
Scrap %:	15.2
Good parts	14,717

Scrap Figures: Critical Parameters for application:

Parameters	100%	Q-Insp	Sum	%
Splits	23	[illegible]	23	0.13
ID Nonfills	122	[illegible]	122	0.70
Axial lip nonf.	34	0	34	0.20
OD nonfill	[illegible]	59	1010	5.82
Torn axial lip	154	0	154	0.89
Torn ID	107	6	113	0.65

Order-no.: 727588	Machine 15 / French Oil	
	Rubber batches	Product. dates
	47394	17.08 - 17.08.00
	17248	31.10 - 01.11.00
	22664	08.11 - 13.11.00
	22664	11.01 - 18.01.01
	47394	13.11 - 20.11.00

Order.no.: 1

Production dates:
Batch numbers:
Pieces molded:
Assembled
Scrap number (total figures)
Scrap %:
Good parts

Scrap Figures: C

Parameters
Splits
ID Nonfills
Axial lip nonf.
OD nonfill
Torn axial lip
Torn ID

Order.no.: 16[illegible]

0919			
Jan-01			
4			
12,254			
4,881			
575			
4.7			
11,678			

ritical Parameters for application:

100%	Q-Insp	Sum	%
45	0	40	0.33
215	55	270	[illegible]
8	0		-
61	2	63	0.[illegible]
0	0		-
13	0	13	0.11

Machine 12 / BIPel	
Rubber batches	Product. dates
27746	30.05 - 0.06.01
22746	06.06 -07.06.01

Order.no.: 133521

Production dates:	Aug-01
Batch numbers	5
Pieces molded	9,725
Assembled	13,081
Scrap number (total figures)	1,332
Scrap %:	13.7
Good parts	8,391

Scrap Figures: Critical Parameters for application:

Parameters	100%	Q-Insp	Sum	%
Splits	333	6	339	[illegible]
ID Nonfills	41	0	41	0.42
Axial lip nonf.	0	0		-
OD nonfill	132	0	132	1.36
Torn axial lip	0	0		-
Torn ID	0	0	0	-

Order.no.: 133521	Machine 13 / BIPel	
	Rubber batches	Product. dates
	80738	24.08 - 25.08.01
	81601 n. axial	19.8 - 23.08.01
	81401 n. axial	16.08 - 19.08.01
	81601 & 80738	23.08 - 24.08.01

Order-no.:275231

Production dates:	Oct / Nov 01
Batch numbers:	[illegible]
Pieces molded:	12,143
Assembled	9,012
Scrap number (total figures)	1,255
Scrap %:	10,3
Good parts	10,888

Scrap Figures: Critical Parameters for application:

Parameters	100%	Q-Insp	Sum	%
Splits	323	22	345	2.8[illegible]
ID Nonfills	216	41	257	2.12
Axial lip nonf.	59	0	59	0.45
OD nonfill	15	4	20	0.16
Torn axial lip	0	0	0	-
Torn ID	56	7	63	0.52

Order-no.:275231	Machine 13 / BIPel	
	Rubber batches	Product. dates
	68067 (68087)	02.11 - 08.11.01
	81601	26.10 - 29.10.01
	80736	29.10 - 02.11.01

Order-no.: All

Production dates:	Sum
Batch numbers:	All
Pieces molded	[illegible]
Assembled	97,[illegible]
Scrap number (total figures)	10,[illegible]
Scrap %:	10.49
Good parts	[illegible]

Scrap Figures: Critical Par

Parameters	100%
Splits	2,[illegible]
ID Nonfills	[illegible]
Axial lip nonf.	[illegible]
OD nonfill	1,515
Torn axial lip	154
Torn ID	1[illegible]

Numb. (

SKF 001734

...meters for application:			
Q-Insp	Sum	% prod	% tot scrap
153	2,6[illegible]	2.[illegible]	[illegible]
1[illegible]2	1,11[illegible]	1.[illegible]	10.7[illegible]
[illegible]	[illegible]	0.[illegible]	[illegible]
[illegible]	1,[illegible]	1.[illegible]	1[illegible].34
[illegible]	1[illegible]4	0.1[illegible]	1.[illegible]
2[illegible]	227	0.2[illegible]	2.1[illegible]
Number:	[illegible]		[illegible]
%	[illegible]		
...o splits)	3,492		
%	3.[illegible]		

Pareto of production scrap:

Defects:	Scrap (No)	Scrap (%)
Bad bond	1,5[illegible]7	16.60
Splits	2,[illegible]50	29.05
ID Nonfills	[illegible]	10.78
Damaged Finger	130	1.43
Undercure	227	2.49
Axial Lip Nonfill	[illegible]	0.99
Torn ID	1[illegible]	2.17
Blister	[illegible]4	6.40
OD Nonfill	1,[illegible]1[illegible]	19.93
Impurity	10	0.11
No Spring	8	0.09
Bent Metal	184	2.02
Rubber on Metal	65	0.71
Rubber Positioning	24	0.2[illegible]
ID Flash	5	0.05
Out of Spec	172	1.8[illegible]
Torn Axial Lip	154	1.69
No Rubber	132	1.45
Pareto Total	9,121	100%
Scrap Number Total:	10,[illegible]0	

Scrap rates: Overview per order

Order-no.: 000203

Production dates:	Feb/Mar 00
Batch numbers:	1
Pieces molded:	19,695
Assembled	17,636
Scrap number (total figures)	1,269
Scrap %:	6.4
Good parts	16,426

Scrap Figures: Critical Parameters for application:

Parameters	100%	Q-insp	Sum	%
Splits	[illegible]	2	3	0.02
ID Nonfills	[illegible]	6	6	0.03
Axial lip nonf.	0	0	0	-
OD nonfill	0	16	16	0.05
Torn axial lip	0	0	0	-
Torn ID	0	1	1	0.03

Sum of critical defects:	Total:	25
% of crit. defects / pieces molded:		0.13
Sum of critical defects without splits:		22
% of crit. defects / pieces molded:		0.11

Order-no.: 727583

Production dates:	April/May 00
Batch numbers:	2
Pieces molded	27,923
Assembled	24,330
Scrap number (total figures)	3,321
Scrap %:	11.9
Good parts	24,602

Scrap Figures: Critical Parameters for application:

Parameters	100%	Q-insp	Sum	%
Splits	1,[illegible]	122	2,[illegible]	[illegible]
ID Nonfills	[illegible]	[illegible]	410	[illegible]
Axial lip nonf.	[illegible]	[illegible]		-
OD nonfill	[illegible]	13	[illegible]	[illegible]
Torn axial lip	[illegible]	[illegible]		-
Torn ID	22	10	32	0.11

Sum of critical defects	3,159
% of crit. defects / pieces molded	11.30
Sum of critical defects without splits	1,102
% of crit. defects / pieces molded	3.95

Order-no.: 727588

Production dates:	Aug 00/ Dec 00 / Jan 01
Batch numbers:	3
Pieces molded	17,356
Assembled	16,268
Scrap number (total figures)	2,638
Scrap %:	15.2
Good parts	14,717

Scrap Figures: Critical Parameters for application:

Parameters	100%	Q-insp	Sum	%
Splits	23	0	23	0.13
ID Nonfills	122	0	122	0.70
Axial lip nonf.	34	0	34	0.20
OD nonfill	951	[illegible]	1010	[illegible]
Torn axial lip	154	0	154	0.89
Torn ID	107	6	113	0.65

Sum of critical defects	1,456
% of crit. defects / pieces molded	8.39
Sum of critical defects without splits	1,433
% of crit. defects / pieces molded	8.26

Order.no.: 10919

Production dates:	Jan-01
Batch numbers:	4
Pieces molded:	12,254
Assembled	4,801
Scrap number (total figures)	576
Scrap %:	4.7
Good parts	11,679

Scrap Figures: Critical Par

Parameters	100%
Splits	49
ID Nonfills	215
Axial lip nonf.	9
OD nonfill	81
Torn axial lip	0
Torn ID	13

...meters for application:		
Q-Insp	Sum	%
[illegible]	48	[illegible]
[illegible]	278	[illegible]
[illegible]		-
2	83	[illegible]
[illegible]		-
[illegible]	13	[illegible]
	408	
	3.31	
	368	
	2.99	

Order.no.: 133521

Production dates:	Aug-01
Batch numbers:	[illegible]
Pieces molded:	9,723
Assembled	13,881
Scrap number (total figures)	1,332
Scrap %:	13.7
Good parts	8,391

Scrap Figures: Critical Parameters for application:

Parameters	100%	Q-Insp	Sum	%
Splits	335	[illegible]	339	[illegible]
ID Nonfills	41	0	41	0.42
Axial lip nonf.	[illegible]	[illegible]		-
OD nonfill	132	[illegible]	132	1.36
Torn axial lip	0	[illegible]		-
Torn ID	[illegible]	0	0	-
			512	
			5.27	
			173	
			1.78	

Order-no.:275231

Production dates:	Oct / Nov 01
Batch numbers:	[illegible]
Pieces molded:	12,143
Assembled	8,012
Scrap number (total figures)	1,255
Scrap %:	10.3
Good parts	10,888

Scrap Figures: Critical Parameters for application:

Parameters	100%	Q-Insp	Sum	%
Splits	323	22	345	[illegible]
ID Nonfills	216	41	257	[illegible]
Axial lip nonf.	50	[illegible]	[illegible]	0.48
OD nonfill	18	4	[illegible]	0.19
Torn axial lip	0	[illegible]	0	-
Torn ID	[illegible]	7	63	0.52
			741	
			6.10	
			396	
			3.26	

Order-no.: All

Production dates:	Sum
Batch numbers:	All
Pieces molded:	[illegible]
Assembled	[illegible]
Scrap number (total figures)	[illegible]
Scrap %:	10.48
Good parts	[illegible]

Scrap Figures: Critical Parameters for application:

Parameters	100%	Q-Insp	Sum	% prod
Splits	2,660	153	2,813	2.83
ID Nonfills	983	132	1,115	1.13
Axial lip nonf.	80	0	[illegible]	[illegible]
OD nonfill	1,810	[illegible]	[illegible]	1.92
Torn axial lip	154	[illegible]	154	0.16
Torn ID	198	29	227	0.23
			6,295	
			6.36	
			3,492	
			3.52	

% lot scrap
[illegible]
10.73
8.87
18.34
1.48
2.10

SKF 001736

Discussion
Mail Topic
Juergen Schultheis/SCH/SKF
07/16 10:39 AM

Subject: **Internal release report for cage: CJ-BTF-0031**

Category: Quality

Hallo Herr Schultheis,

In Anhang finden Sie einen internen Prüfbericht der Komponente über den CJ-BTF-0031.
(Internal release report for the cage: CJ-BTF-0031)

Mit freundlichen Grüßen

Kersten Zuhl

doc0.tif

SKF 001739

SKF GmbH
KWQ

Prüfbericht

Nr. 99 (442

- [ ] Erstbemusterung
- [ ] Versuchsablauf
- [x] Serienbemusterung
- [ ] Dokumentenpflichtige Teile
- [ ]

Produktbezeichnung	Zeichnungs-Nr./Teil-Nr.	Ausführungsvorschrift
Kunststoff - Kunststoffring	03-BTF-0034	
Auftrags-Nr.	**Auftrags-Stückzahl**	**Werkstoff**
810817	45.840	A 3445 schwarz
Lieferant	**Eingangsmeldungs-Nr.**	**SKF-Bestell-Nr.**
Eingangs-Datum	**gelieferte Stückzahl**	**Werkstoff**

Abnehmer:

Anlagen:
- [x] Meßbericht
- [ ] Werkstoffbericht
- [ ]

Bemerkungen

Entscheidung:

- [ ] Freigabe
- [ ] Freigabe mit Auflage
- [ ] Rückweisung
- [ ] Freigabe für Probemontage
- [ ] Freigabe nur für Muster

Reg.-Nr.

wegen:

1 Funktionsfehler	
2 Arbeitsfehler	
3 Werkzeugfehler	
4 Maschinenfehler	
5 Unterlagenfehler	
6 Verfahrensfehler	
7 Werkstoffehler	
8 Prüffehler	
9 Administrativer Fehler	
10 Sonstige Fehler	

30.08.99

Prüfmeister	Qualitätslenkung 31.08.99	Fertigung
31.08.99 Datum / Unterschrift	1.9.2 Datum / Unterschrift	31.8.99 Datum / Unterschrift

Verteiler: KQ-SL, KWQ, KQT

Nr. 2440 · HD

SKF 001740

Betreff/Subject: QUALITAETSPRUEF-ZERTIFIKAT REG-NR: 199908170 1846

SKF GMBH

17.08.1999

POSTFACH 1440

97404 SCHWEINFURT

Geschaeftseinheit KTU
2 08 69
ZERTIFIKATS-NR 1846
SEITE 2 VON 2

WERKSPRUEFZEUGNIS 2.3 NACH EN 10204

ULTRAMID® A3HG6		ARTIKEL-NR	50032700
UNGEFAERBT Q70		PRODUKT-NR	052515.01
1000kg Pappe IBC		KOLLI-NR	21 5 3002
IHRE BESTELLUNG	09.07.1999	ABL.-/LOT-NR	78-7288
54P306761		ABL.-MENGE	5000 KGE
71098110		TOTAL	5000 KGE
FAX V. 13.08.99/ 1:05 UHR		TRANSPORT	MA-PH 850

BASF Aktiengesellschaft
Qualitaetspruefung Ultraplaste/Spinnpolymere
Dr. Lieder (Werkssachverstaendiger)

Dieses Zertifikat wurde automatisch erstellt und ist ohne Unterschrift gueltig.

Discussion
Main Topic

Juergen Schultheis/SCH/SKF
07/16 10:32 AM

Subject: THU production Luechow: quality results 1998

Category: Quality

Hello Mike,
I am in Luechow now and I checked together with C. Zuhl all documentation available for the THU production for 1998 for the THU type: BTF - 0049 A / B.
See attached sheet.

BTF0049_1998.xls

There were no deviations detectable which could indicate special field returns for the THU.
The only deviation we could see is that there were for the order numbers
M 209679 and M214549 raceway crowning values on the lower side of specification.
More detailed information would be available on request.

Best regards
Juergen Schultheis

Auftragsverfolgung BTF-0049 A / B

Type BTF-0049	Auftrag	Start Produktion	Montage / Einlieferung	Mengen
A	M187129	KW 50 / 1997	08.01.98 .. 09.01.98	2500
B	M189112	KW 50 / 1997	23.12.97 .. 30.12.97	1300
A	M187132	KW 02 / 1998	23.01.98 .. 12.02.98	4000
A	M195136	KW06 / 1998	11.03.98 .. 14.03.98	5500
A	M195137	KW 09 / 1998	07.03.98 .. 11.03.98	1800
B	M189111	KW 05 / 1998	28.01.98 .. 18.03.98	4300
A	M196703	KW 02 / 1998	23.01.98 .. 28.01.98	2000
A	M203099	KW 14 / 1998	06.04.98 .. 20.05.98	3500
B	M203100	KW 09 / 1998	14.04.98 .. 17.04.98	2500
A	M209679	KW 16 / 1998	27.06.98 .. 01.07.98	2500
B	M209680	KW 14 / 1998	14.05.98 .. 19.05.98	2500
A	M214549	KW 20 / 1998	20.05.98 .. 26.06.98	4800
B	M214550	KW 21 / 1998	19.06.98 .. 23.07.98	6000
A	M222430	KW 28 / 1998	28.06.98 .. 20.07.98	3000
A	M222431	KW 38 / 1998	22.09.98 .. 26.09.98	4500
B	M222432	KW 39 / 1998	28.09.98 .. 01.10.98	1800
A	M279236	KW 03 / 1999	25.01.99 .. 30.01.99	2500
B	M279237	KW 04 / 1999	30.01.99 .. 05.02.99	2500
				[illegible]

Order numbers for BTF-[illegible] A / B					Inspection Parameters						
Type BTF-[illegible]	Order-No.:	Start Production	Assembly/Del. to warehouse	Quantity	Recess/form 1) Grooving	Roundness 1)	Grease 2) weight	Axial- 3) clearance	Axial- 3) Run out	Radial- 3) Run out	ABS- 3) Run out
A	M167129	KW 50 / 1997	08.01.98 .. 09.01.98	2,500	o.K	o.K	o.K	o.K	o.K	o.K	o.K
B	M169112	KW 50 / 1997	23.12.97 .. 30.12.97	1,300	o.K	o.K	o.K	o.K	o.K	o.K	o.K
A	M167132	KW 02 / 1998	23.01.98 .. 12.02.98	4,400	o.K	o.K	o.K	o.K	o.K	o.K	o.K
A	M195136	KW08 / 1998	11.03.98 .. 14.03.98	[illegible]	o.K	o.K	o.K	o.K	o.K	o.K	o.K
A	M195137	KW 09 / 1998	07.03.98 .. 11.03.98	1,[illegible]	o.K	o.K	o.K	o.K	o.K	o.K	o.K
B	M189111	KW 05 / 1998	28.01.98 .. 18.03.98	4,[illegible]	o.K	o.K	o.K	o.K	o.K	o.K	o.K
A	M199703	KW 02 / 1998	23.01.98 .. 28.01.98	2,[illegible]	o.K	o.K	o.K	o.K	o.K	o.K	o.K
A	M203099	KW 14 / 1998	08.04.98 .. 20.05.98	3,500	o.K	o.K	o.K	o.K	o.K	o.K	o.K
B	M203100	KW 09 / 1998	14.04.98 .. 17.04.98	2,800	o.K	o.K	o.K	o.K	o.K	o.K	o.K
A	M209478	KW 16 / 1998	27.05.98 .. 01.07.98	2,500	[illegible]	o.K	o.K	o.K	o.K	o.K	o.K
B	[illegible]	KW 14 / 1998	14.05.98 .. 19.06.98	2,500	o.K	o.K	o.K	o.K	o.K	o.K	o.K
A	M214549	KW 20 / 1998	20.05.98 .. 26.06.98	4,[illegible]	[illegible]	o.K	o.K	o.K	o.K	o.K	o.K
B	M214550	KW 21 / 1998	19.06.98 .. 23.07.98	[illegible]	o.K	o.K	o.K	o.K	o.K	o.K	o.K
A	M222430	KW 28 / 1998	20.08.98 .. 20.07.98	[illegible]	o.K	o.K	o.K	o.K	o.K	o.K	o.K
A	M222431	KW 38 / 1998	22.09.98 .. 26.09.98	[illegible]	o.K	o.K	o.K	o.K	o.K	o.K	o.K
B	M222432	KW 39 / 1998	28.09.98 .. 01.10.98	1,800	o.K	o.K	o.K	o.K	o.K	o.K	o.K
A	M279236	KW 03 / 1999	25.01.99 .. 30.01.99	2,500	o.K	o.K	o.K	o.K	o.K	o.K	o.K
B	M279237	KW 04 / 1999	30.01.99 .. 05.02.99	2,500	o.K	o.K	o.K	o.K	o.K	o.K	o.K
				57,[illegible]							

Remarks:

1) 1 piece for first off. 1 piece 2 times per shift for grinding and boring.

2) Parameter controlled by SPC chart. Sampling: 1 piece per hour.

3) 100% measuring automatics with control limits 6ym less than tolerance limit. In case of deviation production stopped. Corrections on THU have to be made.

SKF 001747

Discussion
Main Topic

Juergen Schultheis/SCH/SKF
07/18 10:28 AM

Subject:	Roller quality delivered from SKF Veenendaal
Category:	Quality

Enclosed I send you a summary of the historical quality data of rollers RT-502 IIIL/VK4511, that we have produced for SKF Aiken.
I hope this information is OK. If not, then please call me.

Historical data RT-502.doc

Best regards,

Nico van Manen
SKF Kogellagerindustrie/Veenendaal/The Netherlands
(Tel: +31 (0)318 532105, Fax: +31 (0)318 532112)
(Email: nico.van.manen@skf.com)

SKF

SKF Kogellagerindustrie	**Memo**	1(2)

From
Nico van Manen
Quality Assurance

2002.07.10

Ref

To
Jürgen Schultheis

Subject
Historical quality data of RT-502/IIILVK4511

1. Deliveries to SKF Aiken

In February 2000 SKF Kogellagerindustrie started to deliver RT-502 /IIILVK4511 rollers to SKF Aiken. Before that period, SKF Glasgow delivered these rollers.
Difference between Veenendaal rollers and Glasgow is the heattreatment; Glasgow delivered case-carburized rollers and Veenendaal delivers martensic through-hardened rollers.
The following quantities have been delivered:

Date:	Number of pieces:	Ordernumber:
2000/02	53,000	221205
2000/03	53,000	221206
2001/06/27	390,000	W358712
2001/07/23	125,000	W366539
2001/10/16	15,025	W404213
2001/11/12	275,000	W412406
2002/02/12	325,000	W442108
2002/03/18	300,000	W448242
2002/04/08	250,000	W462072

2. Results of productaudits

Product audits are performed during the several production runs. They are randomly taken and the results are following:

Date:	Channel:	Ppk:										
		Pw	LSC delta r	W2	W3	W4	W5	W6	W7	R1 wmax	R2 wmax	R3 wmax
00/11/07	33	2.57	2.0	3.9	1.6	4.6	7.2	2.5	6.0	7.6	6.3	3.2
01/06/27	9	8.12	3.7	6.4	3.1	3.5	2.6	1.7	1.3	1.6	2.0	5.5
01/0723	9	4.96	2.1	3.2	2.3	3.3	3.7	1.4	2.2	2.2	2.9	2.9
01/0831	9	5.91	3.3	3.5	8.3	4.4	6.1	2.5	3.7	4.4	6.0	5.3
02/04/09	9	1.82	3.3	4.3	5.9	3.7	3.0	2.2	2.2	1.2	1.8	3.4

Explanation:

Pw	= convexity of raceway profile
LSC delta r	= unroundness of raceway
W2	= 2nd harmonic unroundness of raceway
W3	= 3rd harmonic unroundness of raceway
W4	= 4th harmonic unroundness of raceway
W5	= 5th harmonic unroundness of raceway
W6	= 6th harmonic unroundness of raceway

Discussion

Main Topic

Juergen Schulthess/SCH/SKF
07/18 10:26 AM

Subject: Roller quality delivered from Glasgow

Category: Quality

To: Christopher.Jones@skf.com, Jurgen.Schulthess@skf.com
cc: mwallace@rbcbearings.com
Subject: Re: Quality of conformance for RT 502 L

Gentlemen,

1. From the Glasgow plant, we supplied the 502IIIDB225 roller to SKF Aiken as follows:

Month	Quantity
Dec. 98	476,066
Jan. 99	624,214
Feb. 99	680,314
Mar. 99	803,931
April 99	515,153
May 99	619,238
June 99	828,124
July 99	213,012
Aug. 99	523,153
Sept. 99	470,272
Oct. 99	293,838
Nov. 99	787,417
Dec. 99	111,773

2. Product Audits

During the grinding operation product audits were conducted continuously. If a non conformance was found that product was not used. We are faxing to Chris Jones examples of the summary sheets for our ongoing audits. Backup data including traces are still available for these summaries.

3. Material Certificates

Material certificates were, and are reviewed when the raw material is received. There were no non-conformances.

4. Heat Treat

Every heat of rollers was inspected in the met. lab. and no non-conformances were found.

5. PPAP

The final PPAP for the Aiken Truck Hub including the rollers was March 1998.

Best Regards,
Ed

Discussion Main Topic Juergen Schultheis/SCH/SKF 07/16 09:51 AM	**Subject:**	**RFT investigation result for R-safe seals from CR-Bethlehem**
	Category:	Quality

Extract:

RFT Quality Department received 50 pieces, in 5 plastics bags, in order to perform a visual expect analysis on them.

Conclusions

Results:

- 50 pieces verified.

- 10 pieces with defects. The seals analysis shows that only one piece (2% of all the pieces analyzed) is defective on both the lips (axial and radial). This is the only one that can have a risk of early water ingress. The other 9 pieces have defects that, being only on a lip, have very little influence on early water ingress.

The main defects found on the pieces are due to a manual deflashing operation not properly performed or to vulcanization.
All the good and defective pieces are identified and are available in Plant Quality Assurance VLN.

report beth lv.doc

Best regards
P. Spadaccini

Report (12/04/02)

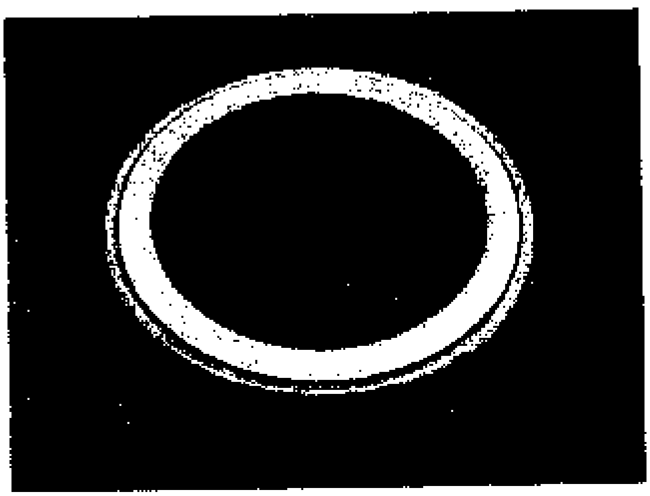
Item SV-BTFB 446329 CD
Bethlehem Production

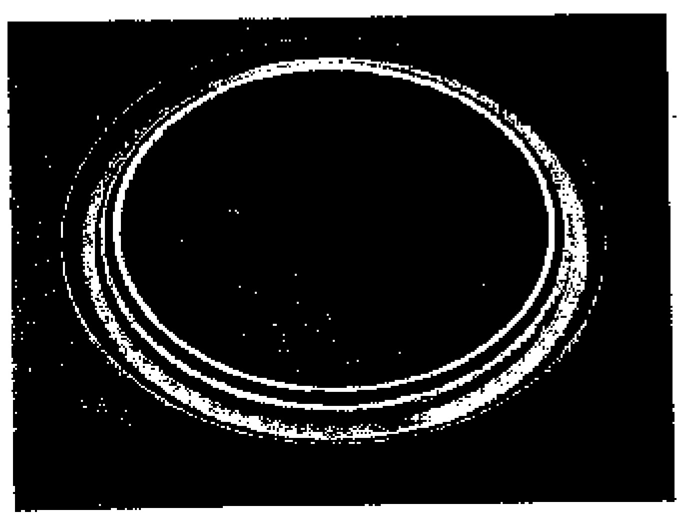
Report by G. Ceresa and A. Zampieri

Visual Aspect Analysis

RFT Quality Department received 50 pieces, in 5 plastics bags, in order to perform a visual expect analysis on them.

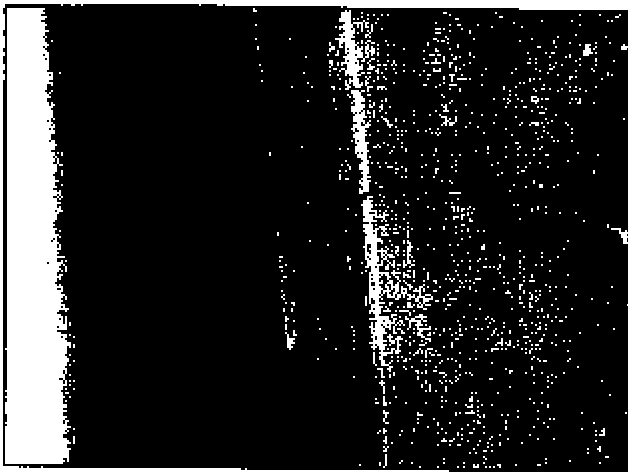
Photos of the Item:



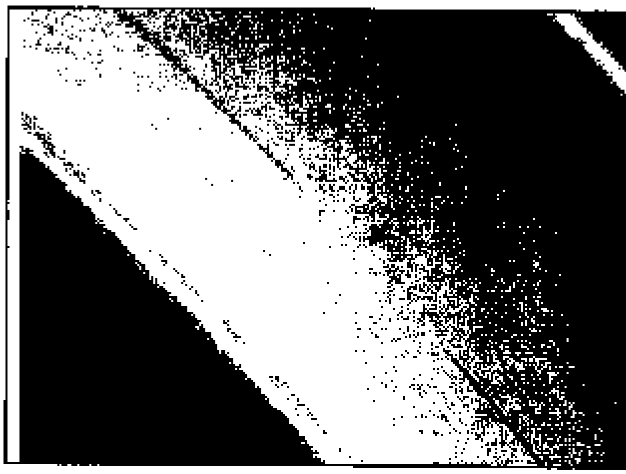


Photos of the defective pieces

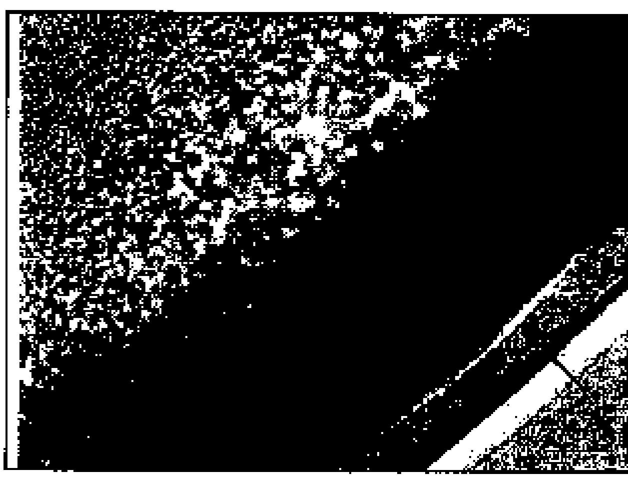
Here below some photos of the 10 defective pieces with comments.



Piece	1
NOTE: The radial lip is interrupted – probably cut by a knife during the deflashing operation Measured: 5.17 mm length, 0.37 mm height , 0.075 mm depth.	



Piece	1.1
NOTE: Mounting the piece on a Plexiglas mandrel it's possible to see the sealing lip interrupted.	

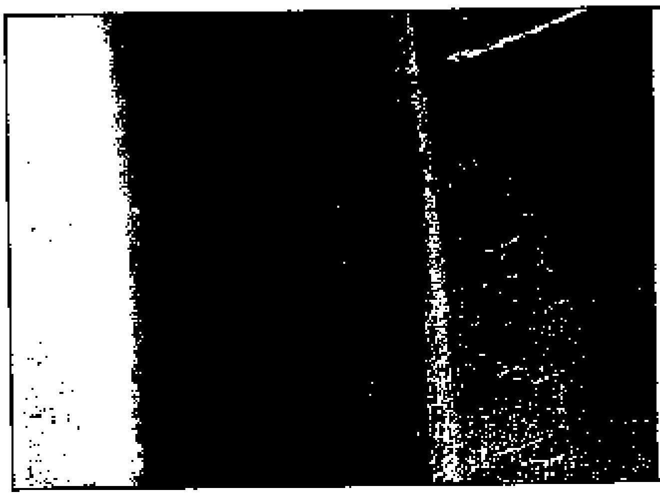


Piece	2
NOTE: The radial lip is not uniform – defect originated during vulcanization	

SKF 001755

Piece	3
NOTE: Photo 1: The rubber flash is out of tolerance – pieces non properly deflashed	

Piece	3.1
NOTE: Photo 2: The radial lip is not uniform – defect originated during vulcanization	



Piece	4
NOTE: The radial lip is interrupted – probably cut by a knife during the deflashing operation	

SKF 001756

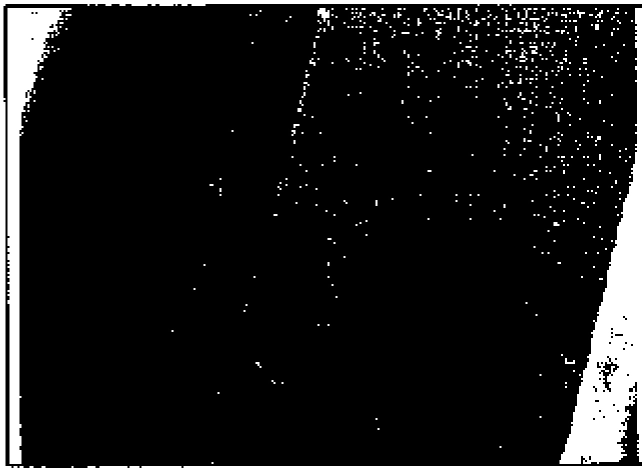
Piece	5
NOTE: The radial lip is interrupted – probably cut by a knife during the deflashing operation -	

Piece	6
NOTE: Axial lip incomplete (lack of material) – defect originated during vulcanization	

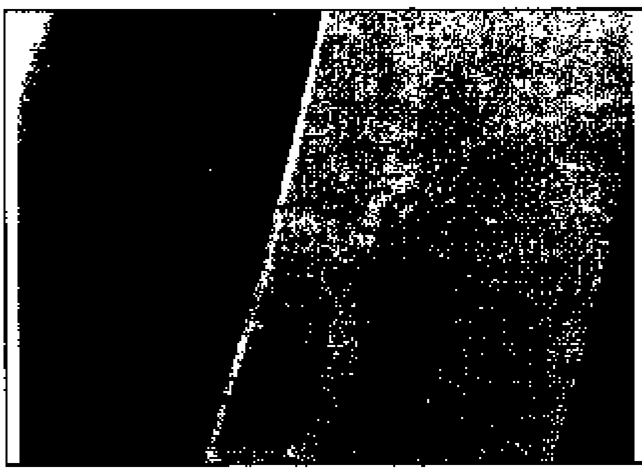
Piece	7
NOTE: The radial lip is interrupted – probably cut by a knife during the deflashing operation -	

SKF 001757

Piece	8
NOTE: The photo shows the radial lip. The radial lip is interrupted – probably cut by a knife during the deflashing operation – There is also a lack of material on the axial lip – defect originated during vulcanization Measured: 17.0 mm length, 0.30 mm height, 0.09 mm depth.	



Piece	9
NOTE: The radial lip is not uniform – defect originated during vulcanization	



Piece	10
NOTE: The radial lip is not uniform – defect originated during vulcanization	

SKF 001758

Conclusions

Results:

- 50 pieces verified.

- 10 pieces with defects. The seals analysis shows that only one piece (2% of all the pieces analyzed) is defective on both the lips (axial and radial). This is the only one that can have a risk of early water ingress. The other 9 pieces have defects that, being only on a lip, have very little influence on early water ingress.

The main defects found on the pieces are due to a manual deflashing operation not properly performed or to vulcanization.
All the good and defective pieces are identified and are available in Plant Quality Assurance VLN.

SKF 001759

Discussion
Main Topic

Juergen Schultheis/SCH/SKF
07/16 09:14 AM

Subject: Audit report: CR Elgin / CR Bethlehem / Defect rate on R-safe seals

Category: Quality

Attached an draft of the audit report for
- CR Elgin
- CR Bethlehem
- Investigation results for R-safe seals (percentage of defect seals delivered to AM)

Report as an draft has to be checked before hand out to customer !!

auditreport_beth.doc

Audit report:
R-safe seals made by CR-Bethlehem

Subject:
Water ingress on THU manufactured in SKF Aiken for customer Arvin Meritor caused by deviations on R-safe seals manufactured in CR-Bethlehem.

It was decided by BU-Truck management to carry out an process audit at CR-Elgin and CR-Bethlehem with the target to investigate, if there were possible process changes, quality problems during production of the different seal batches causing the problem in the THU application.

Process audit at CR Elgin: **(preparation of rubber batches)**
Date: 24. 04 up to 26.04 02
Auditors: Johann Kirch (Quality manager of CR-Elastomere Leverkusen - Germany)
Juergen Schultheis (Quality manager of Business Unit Truck - Germany)

Main scope of the audit:
Preparation of the different rubber batches in CR-Elgin for the R-safe seal manufactured in CR-Bethlehem.
The audit included following operation steps:

* **In coming material**
(released suppliers, in coming inspection activities; release of material batches, labeling of material batches, storage of material batches, first-in first-out principle, control of defined storage times)

* **Preparation and release of rubber material**
(usage of defined raw materials/quantities according to receipt, process parameters, q-documents, material traceability , approval inspection, labeling system)

* **Investigation of rubber material**
(Investigation-/ evaluation principles, laboratory equipment, calibration routine, qualification)

Conclusions of the findings:

Investigation results of the different rubber batches produced in CR-Elgin showed no deviations outside defined specifications that indicates possible problems due to machineability during seal production carried out in CR-Bethlehem.

Process audit at CR Bethlehem: **(manufacturing of seals)**
Date: 22. 04 up to 23.04. 02
Auditors: Johann Kirch (Quality manager of CR-Elastomere Leverkusen - Germany)
Juergen Schultheis (Quality manager of Business Unit Truck - Germany)

Main scope of the audit:
Manufacturing of R-safe seals.
The audit included following operation steps:

* **In coming inspection of**
- **rubber batches for the R-safe seal prepared in CR-Elgin.**
- **stampings**
- **springs**

(certification check, release of batches, storage and labeling of batches, FIFO-principle)

* **Preparation of rubber tubes and rubber rings**
  (work procedures, process parameters, inspection activities)

* **Molding process**
  (machine setting, process parameter control, visual inspection, maintenance activities, possible process changes)

* **Visual inspection activities after molding:**
  (inspection conditions, inspection plans, critical/main parameters , visual aids, scrap rates)

Conclusions of the findings:

No process changes could be seen during production of the different seal batches. A continuous scrap rate could be seen with defects comparable to the defects causing the "early" failures of the truck hub unit. There was no special production lot or used rubber batch that has shown an exceeded scrap level. Due to the fact that a 100% visual inspection by human being is not sufficient enough to select out all seals with defects / deviations , it must be assumed that seals with defects has left CR-Bethlehem during the complete production period of the seal.

Seals with possible defects delivered through SKF Aiken to customer Arvin Meritor:

The last production lot from CR-Bethlehem was available in SKF Aiken. This production lot was blocked. Samples (50 pieces) out of production lot were sent to CR- Leverkusen and RFT for quality investigation.

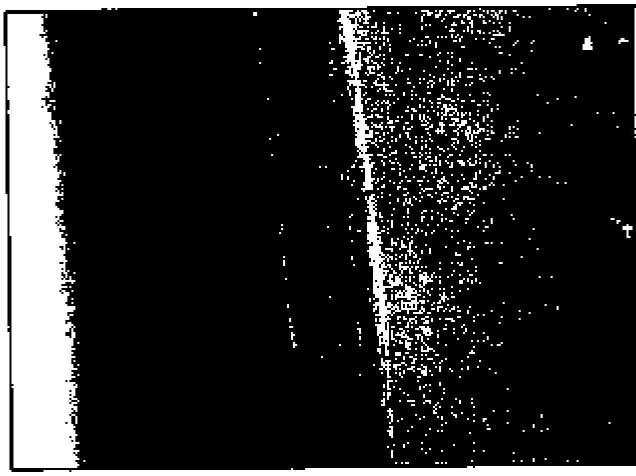
Investigation results:
The investigation results show that appr. 20% of checked seals have shown deviations, either on axial lip or radial lip. Experiences in greased seal application have shown, that these kind of deviations will not lead to water ingress during application (self healing process).

2 % of seals may have defects that could lead to early water ingress in the THU application due to the fact that on that seals deviations were found on both seal lips (axial and radial). These kind of defects were visible on returned and investigated parts from the field.

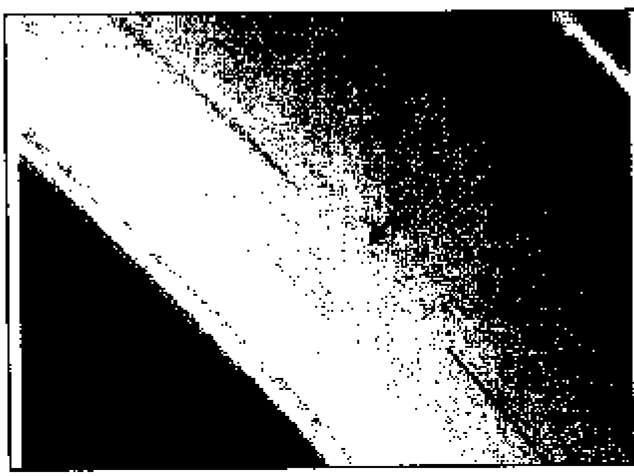
Samples of deviations see photos attached.

Photos of the defective pieces

(Report (12/04/02) from RFT (G. Ceresa and A. Zampieri)
Here below some photos of the 10 defective pieces with comments.



Piece	1
NOTE: The radial lip is interrupted – probably cut by a knife during the deflashing operation Measured: 5.17 mm length, 0.37 mm height , 0.075 mm depth.	

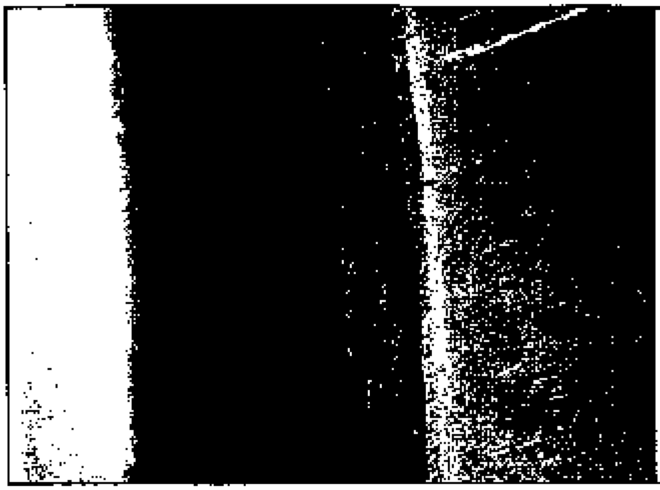


Piece	1.1
NOTE: Mounting the piece on a Plexiglas mandrel it's possible to see the sealing lip interrupted.	

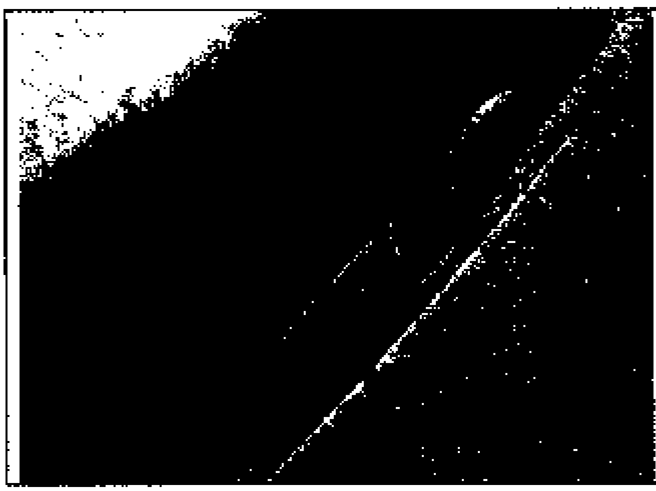
Piece	2
NOTE: The radial lip is not uniform – defect originated during vulcanization	

Piece	3
NOTE: Photo 1: The rubber flash is out of tolerance – pieces non properly deflashed	

Piece	3.1
NOTE: Photo 2: The radial lip is not uniform – defect originated during vulcanization	

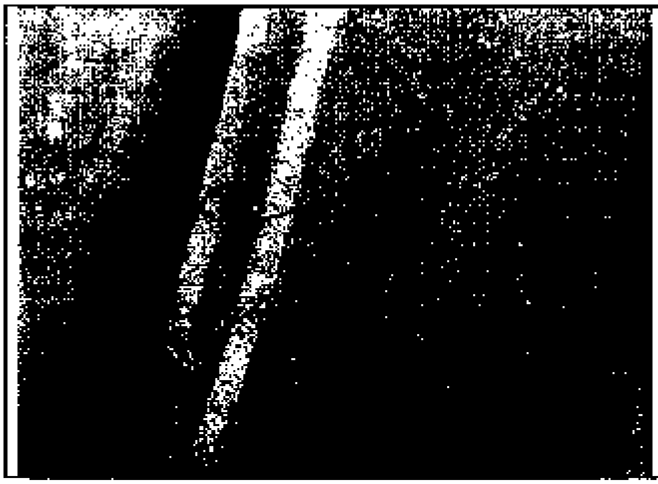


Piece	4
NOTE: The radial lip is interrupted – probably cut by a knife during the deflashing operation	



Piece	5
NOTE: The radial lip is interrupted – probably cut by a knife during the deflashing operation -	

Piece	6
NOTE: Axial lip incomplete (lack of material) – defect originated during vulcanization	



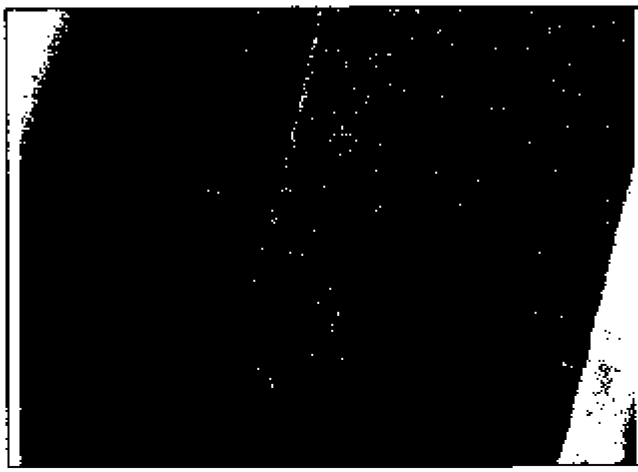
Piece	7
NOTE: The radial lip is interrupted – probably cut by a knife during the deflashing operation -	

Piece	8 (critical defect)

NOTE: The photo shows the radial lip. The radial lip is interrupted – probably cut by a knife during the deflashing operation –

There is also a lack of material on the axial lip – defect originated during vulcanization

Measured: 17.0 mm length, 0.30 mm height, 0.09 mm depth.



Piece	9

NOTE: The radial lip is not uniform – defect originated during vulcanization

Piece	10
NOTE: The radial lip is not uniform – defect originated during vulcanization	

Response
to Main Document

Achim Mueller/SCH/SKF
07/09 05:50 AM

Subject: Air Leak Test

Response to: Inspection and Test Reports

Category:

st02t205.doc

AIRLEAK TEST ON FF98X KNUCKLE

SKF GmbH
Gunnar-Wester-Str.12
D-97419 Schweinfurt, Germany
Tel.: +49 (9721) 56-0

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Requested by **Requester**		
Project Project Titel		
Reported by	Supervised by	Approved by
Achim Müller/ATT-PK		**A. Stubenrauch / ATT**
Copies to		
Michael D. Lewis	ADNA	SKF NATC
Achim Müller	ATT-PK	SKF Schweinfurt
Archiv	MWI	SKF Schweinfurt

st02t205 3595264kB Achim Müller

Content

Tabellen und Bilder

Key words: ArvinMeritor, Truck Hub Unit, water ingress, leak path, air leak test

THU,

Background

ArvinMeritor is claiming an unacceptable level of progressive bearing damages on their FF98X non driven front steer axles. The discussed SKF product is a so called "full flanged" Truck Hub Unit.

During a visual inspection of returned field parts (see report ST 02 T 206), it was found out that the vast majority of parts shows damage related to water ingress into the bearing. In contradiction to earlier inspections, a leak path along the inboard inner ring side face and the spindle was concluded to be a main contributor to the presence of water in the bearing.

Purpose of the Test

To prove potential leak paths for water entering the bearing cavity.

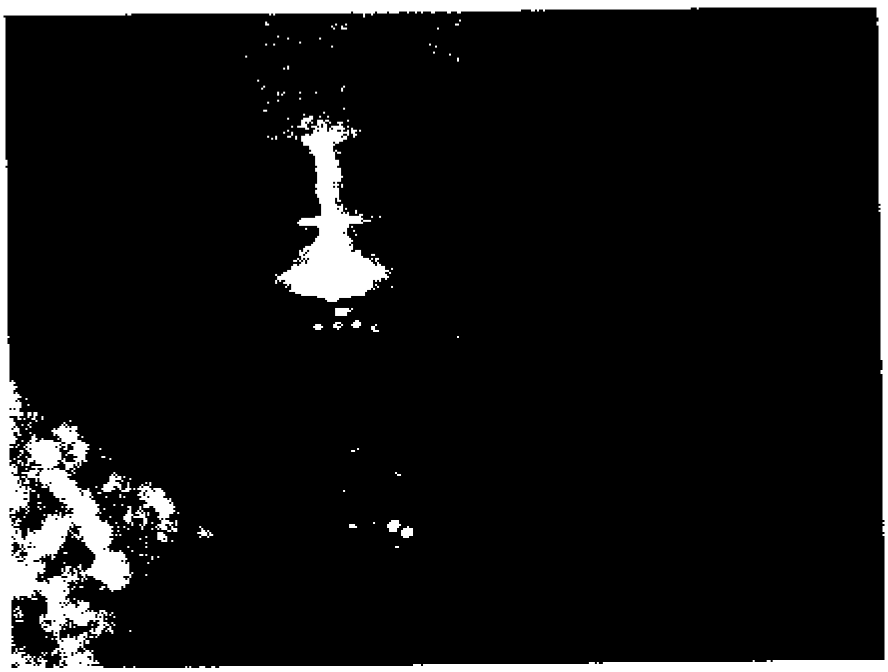
Test Description

A new SKF Truck Hub Unit BTF-0065 was installed onto a new ArvinMeritor FF98X knuckle. The bearing was clamped with a torque of 600 ft-lbs applied to the inner locking nut. A coupling for pressurized air was installed into a hub cap and the hub cap was then installed with a torque of 110 ft-lbs (see picture 1).

Pressurized air (0.5 bar) was lead into the hub cap cavity. A leak detection spray was applied onto the inboard side and the hub cap of the installed unit. The test was repeated also with a used hub cap.

Results

The formation of foam indicates the presence of leak paths along the spindle and the inner ring side face as well as along the hub cap thread (see pictures 2 to 4).



Picture 2: Foaming leak detection spray at unit side face

Picture 3: Foaming leak detection spray on new hub cap

SKF 001774

Picture 4: Foaming leak detection spray on used hub cap

It is to be noted that this test is a static test only. It is assumed that dynamic effects caused by driving and braking of the vehicle are enforcing the observed leakages.

Conclusion

The foam formation of the leak detection spray on both the unit side face and the hub cap indicates two potential leak paths for water entering the bearing. One is along the inner ring side face and the spindle, the other is through the hub cap thread.

Response to Response

Bruce Weeks/AMER/SKF
07/23 04:25 PM

Subject: Oversize hubcap threads - Air leak test at NATC

Response to: Air Leak Test

Category:

I did a leak test on oversize hubcap threads with both plastic and aluminum hubcaps.

BTF-0052 with hubcap threads 200 microns over maximum tolerance
Spindle lightly greased with SKF LGEP2 (NLGI 2) grease
Hub unit torqued to 650 ft-lbs (min spec)

Test set-up leak test setup.jpg

Plastic hubcap torqued to 75 ft-lbs
5 psi - no bubbles at cap or spindle shoulder
10 psi - no bubbles at cap, very slight bubbling at spindle shoulder
15 psi - no bubbles at cap, very slight bubbling at spindle shoulder

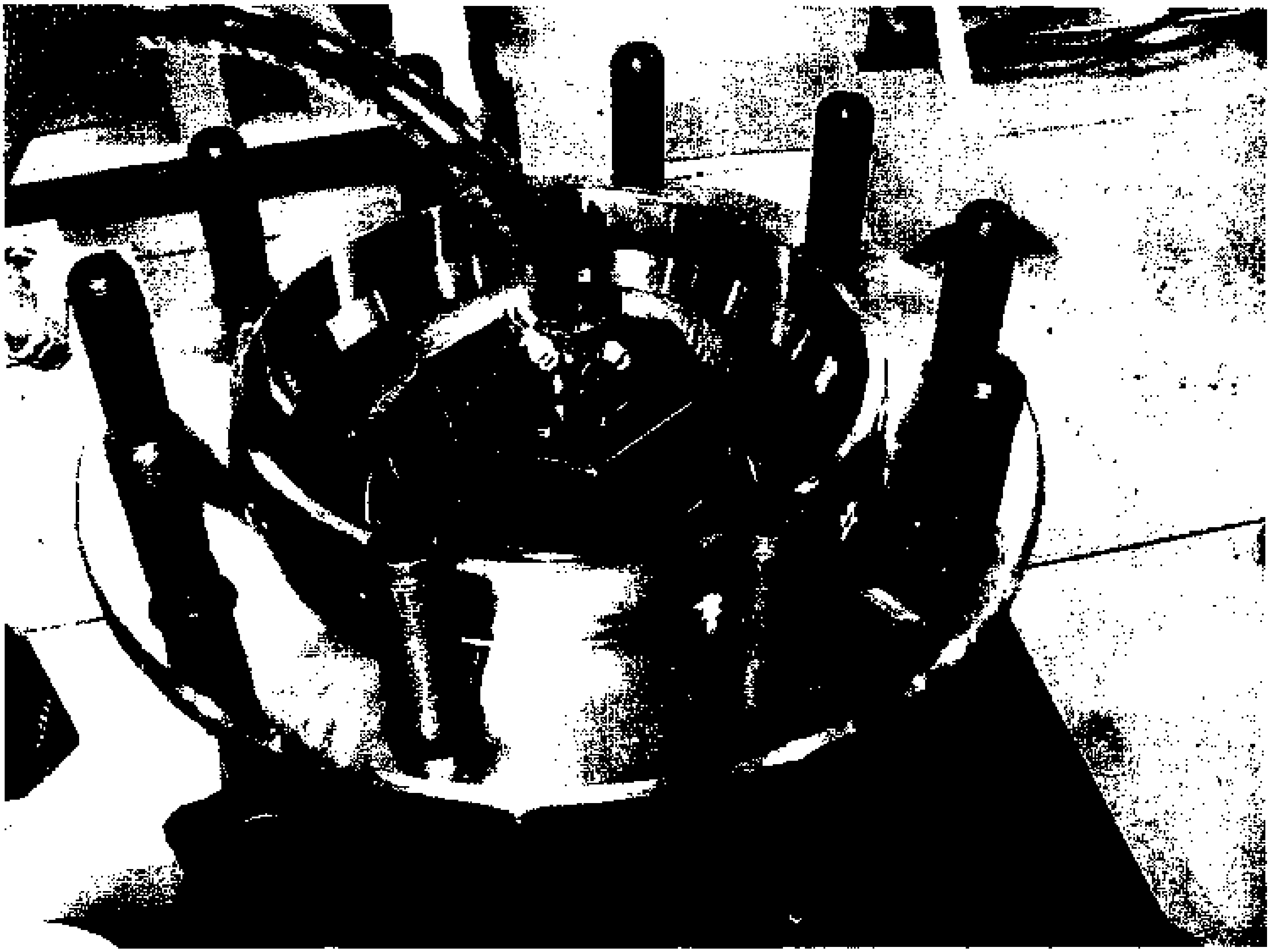
Hubcap at 1 bar (15 psi) plastic hub cap leak.jpg

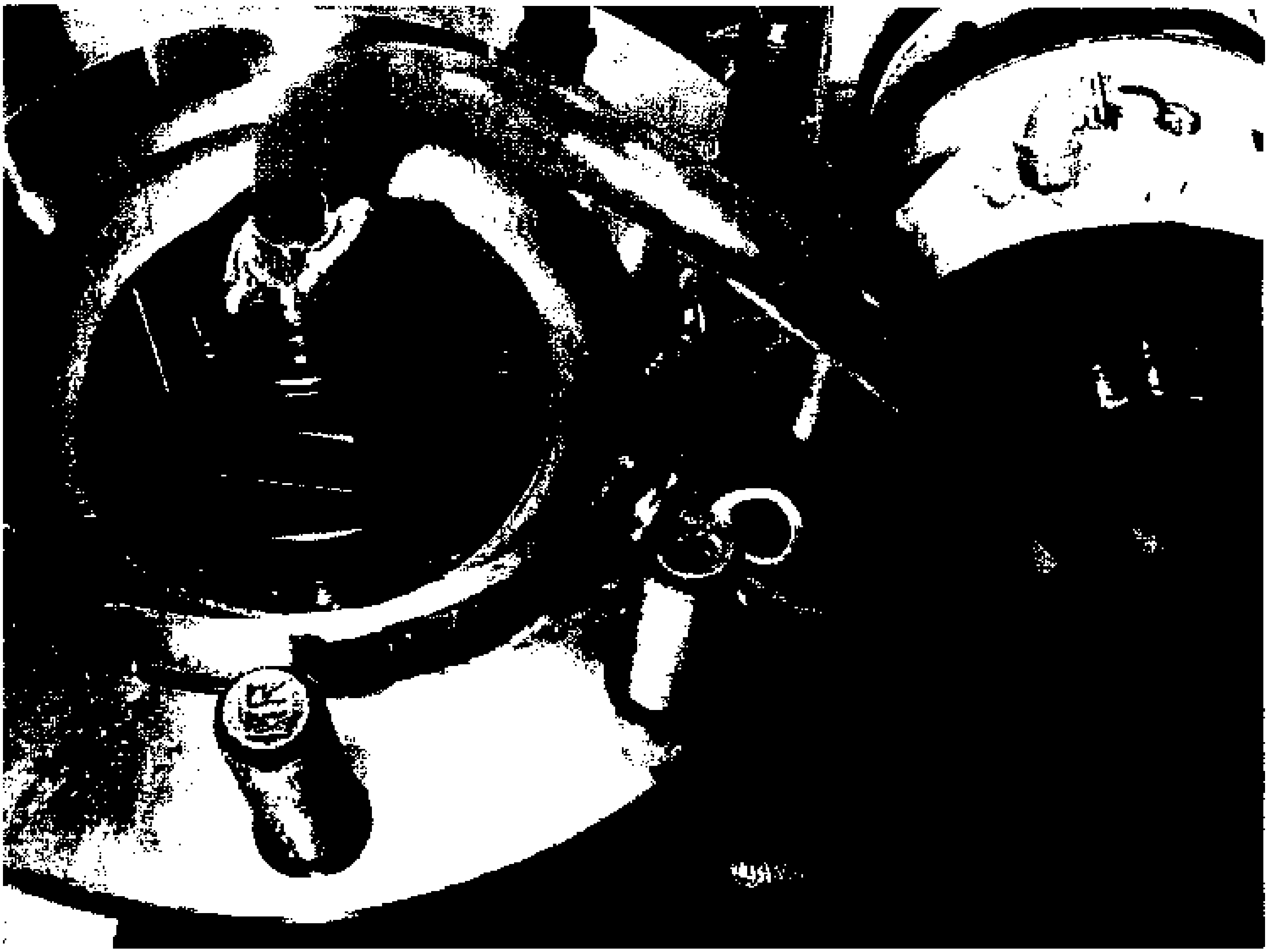
Spindle shoulder leaking at 0.67 bar (10 psi) spindle leak.jpg

This spindle was used in the field, and has not been measured for perpendicularity or roughness.

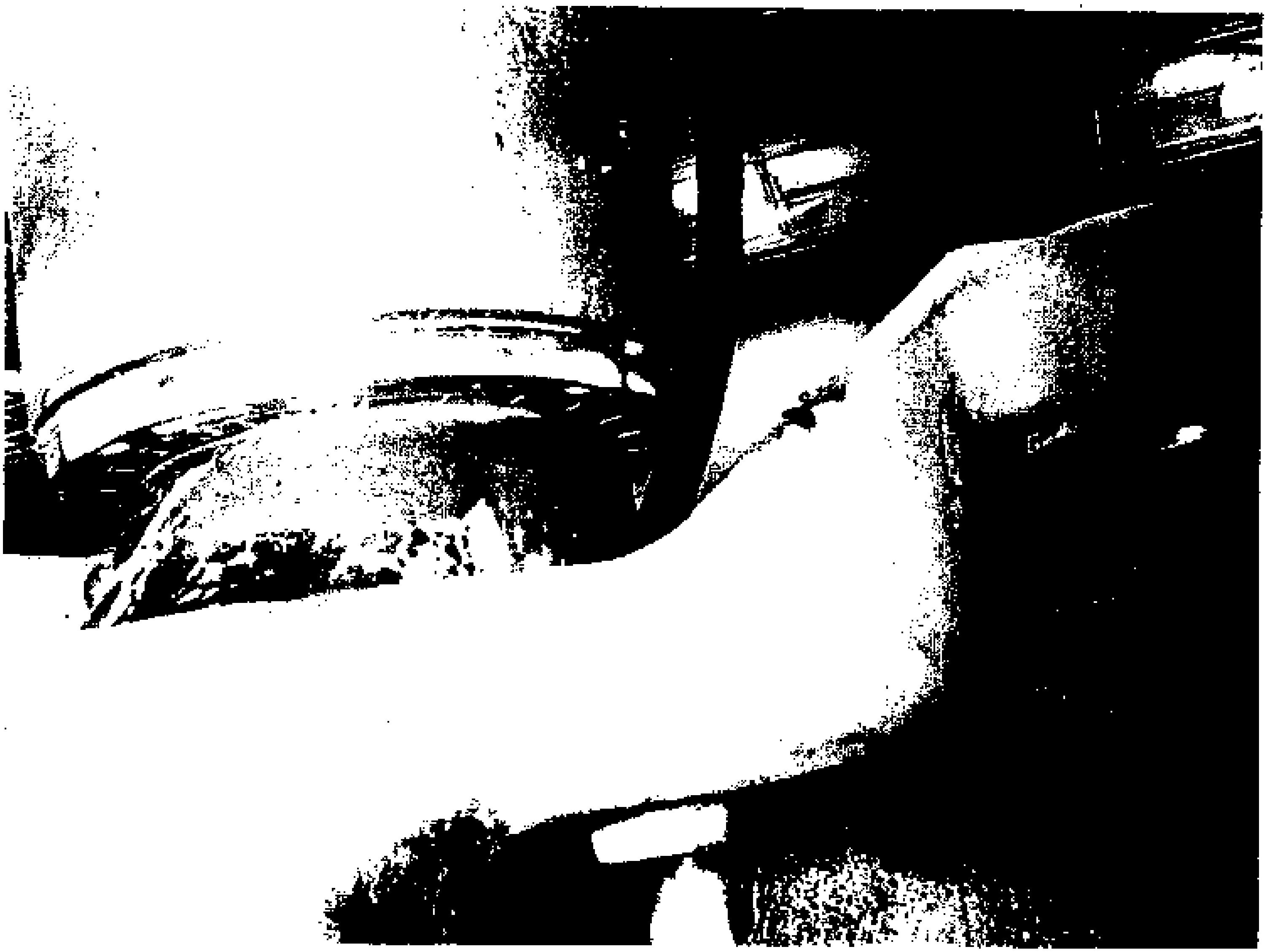
Aluminum hubcap torqued to 250 ft-lbs (original spec)
3 psi - bubbles at hubcap

Aluminum hubcap leaking at 0.2 bar (3 psi) alum hub cap leak.jpg





SKF 001776



SKF 001780

Response
to Main Document

Achim Mueller/SCH/SKF
07/09 05:54 AM

Subject:	Visual Inspection of Returned THUs
Response to:	Inspection and Test Reports
Category:	

st02t206.doc

SKF 001781

VISUAL INSPECTION OF RETURNED THU INNER R INGS

Origin: Ryder, Big Springs

SKF GmbH
Gunnar-Wester-Str.12
D-97419 Schweinfurt, Germany
Tel.: +49 (9721) 56-0

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Requested by Requester Project Project Titel		
Reported by Achim Müller/ATT-PK	Supervised by	Approved by A. Stubenrauch / ATT
Copies to		
Michael D. Lewis Achim Müller Archiv	ADNA ATT-PK MWI	SKF NATC SKF Schweinfurt SKF Schweinfurt

st02t206 55808kB Achim Müller

Content

Tabellen und Bilder

Key words: ArvinMeritor, Truck Hub Unit, Ryder, Visual Inspection

Purpose of the Inspection

To verify findings of earlier visual inspections performed by ADNA personal. In total 13 inboard inner rings, roller complements and seals of Truck Hub Units BTF-0032 were returned. These bearings have been identified earlier to be spalled, thus not reaching the expected service life of a million miles. It had been determined that the spalls are caused by lubricant film break down due to water ingress through the inboard seal.

Findings of Visual Inspection

Hereunder are listed the findings and conclusions of the visual inspection performed in the Schweinfurt test laboratory. To identify individual bearings, the findings are summarized under the respective claim number and mileage.

E1752364 308,528 miles

Two shallow spalls in roller distance over 3/4 of the inner ring raceway length. The seal main lip wear is 0.6 mm wide. No signs of corrosion on seal counterface. Corrosion is found in the clip ring groove.

Shallow raceway spalls are indicating surface distress. Such a damage is typically caused by either vibrations or lubricant film break down. The most common reason for lubricant film break down is the presence of water in the bearing. The presence of rust in the bearing bore and the appearance of the seal are indicating a leak path along the axle.

Ryder 3617 393,580 miles

Ring and roller raceways as well as the guiding flange are in good condition. The seal main lip wear is 3.1 mm wide. The seal counterface is partially corroded. No corrosion is found in the clip ring groove.

The bearing has not failed yet. The heavily worn seal indicates a reduced sealing function, allowing water and other contamination entering the bearing.

E1755559 438,500 miles

The guiding flange is heavily worn over about 90° of the circumference ("hot runner"). Ring and roller raceways are in good condition. The seal main lip wear is 0.6 mm wide. Corrosion is found in the clip ring groove. No evidence of water in the bearing. Fretting corrosion in the bearing bore is indicating two load zones.

Seizing on guiding flange surfaces is considered to be an unusual occurance. It may be caused by either heavy axial loading, extremely high preload (clamp load), lubricant film break down or misaligned mating parts (perpendicularity of spindle and shoulder). Due to the good overall appearance of the bearing components, lubricant film break down is an unlikely root cause for the damage. Two load zones typically show up when the bearing is disassembled and put back onto the spindle.

Ryder 33623 615,339 miles

Ring and roller raceways as well as the guiding flange are in good condition. The seal main lip wear is 1.6 mm wide. The seal counterface appears to be in good condition. The clip ring groove is not corroded. No evidence of water ingress is found. However, there are traces of over rolled particles.

The source of those particles could not be clarified. The findings on this bearing do not lead to a conclusion.

SKF 001764

Ryder 33620 482,615 miles

One shallow spall over about 130° of the ring raceway. The areas close to the spall appear shiny. The seal main lip wear is

2.8 mm wide. The seal counterface is not corroded. Rust can be found in the clip ring groove. The ring and the seal are damaged by disassembly tools.

Shallow spalls and/or shiny, mirrorlike, raceways are indicating a lubricant film break down. Both, the shiny raceway surface and the heavily worn seal, are indicating water ingress into the bearing. There is, however, also evidence of a leak path along the spindle.

E1755522 403,200 miles

One shallow spall over about 160° of the ring raceway. In addition, the guiding flange is heavily worn over about 90°. The seal main lip wear is 2.7 mm wide, the main lip is torn away over about 90° of the circumference. Rust can be found in the clip ring groove.

Shallow spalls are typical for lubrication problems. The heavy seal wear indicates contamination ingress into the bearing, there is also evidence of a leak path along the spindle.

E1752375 273,721 miles

The ring raceway is spalled over about 90° of its circumference. The roller raceways are shiny. A 2 cm long particle (chip?) is found in the guiding flange undercut. The seal main lip wear is 1.6 mm wide. The seal counter face appears in good condition, however, the trace of the dust lip shows some corrosion. Rust is found in the clip ring groove.

Shiny raceways are evidence of lubricant film break down. Both corrosion traces, on the seal counterface and the bearing bore, indicating potential leak paths.

E1750339 689,347 miles

The ring raceway is spalled over about 90° of its circumference. The seal main lip wear is 3.8 mm wide. The seal counterface is heavily corroded. Rust is present in the clip ring groove. The roller raceways are shiny. The seal main lip exhibits several voids, up to five mm long, on the bearing side.

The spall appears to be caused by lubricant film break down due to water entering the bearing. The voids in the seal lip may be explained by roller skewing as a consequence of the spall.

CWA06549 385,007 miles

The ring raceway is spalled, while the roller raceways are shiny. The seal main lip wear is 1.3 mm wide. The seal counter face is in good condition. Rust can be found in the clip ring groove.

Shallow spalls and shiny raceways are indicating a lubricant film breakdown due to water ingress. A leak path along the spindle appears to be possible.

CWA07833 mileage ?

Ring and roller raceways are in good condition. The guiding flange is seized. The seal main lip wear is 3.0 mm wide. The seal counter face appears to be in good condition. The seal spring is missing. Only little rust can be seen in the bearing bore.

The reason for this damage is not determined. The seal is heavily worn. However, since the mileage of the bearing is not known, a conclusion about the seal performance is hardly possible.

E1744715 268,745 miles

The appearance of the raceways and the guiding flange is good. Traces of over rolled particles are to be seen. The seal main lip wear is 0.9 mm wide. The seal counterface is in good condition. Rust can be found in the clip ring groove. The dust lip of the seal has a five mm long cut.

The source of those particles could not be clarified. The findings on this bearing do not lead to a conclusion.

E1752410 192,639 miles

The raceways are shiny, while the guiding flange is seized. The seal main lip wear is 3.5 mm wide. The seal counterface is heavily corroded. The bearing bore is also heavily corroded. Multiple dark lines on the ring raceway in roller distance are indicating contact corrosion between rollers and ring raceway.

The overall appearance of the bearing components leads to the conclusion that the bearing was submerged in water. Free water was present in the bearing, causing a lubricant film break down. Since multiple lines of contact corrosion can be seen, it can be assumed that the bearing was operating for a while after the submersion happened.

E1727708 1,165,585 km

The ring raceway is polished. Reaction layers on the roller raceways are indicating elevated operation temperatures. The seal main lip wear is 3.6 mm wide. The seal counterface is corroded.

The appearance of the bearing is typical for a lubricant film break down. The heavy seal wear supports the assumption that water passed the seal lip.

Summary

A total of 13 returned bearing cones and seals have been inspected. All of those bearings had been classified by ADNA as being damaged after inboard seal leakages.

The findings reported above do not fully support this earlier assessment.

It may be confirmed that the vast majority of the bearing damages are due to lubricant film break down caused by water intrusion into the bearing. It is, however, not verified in all cases that water entered the bearings through the seal. There is also a potential leak path along the spindle.

This conclusion is supported by the presence of rust in the inner ring's clip ring groove and the good overall appearance of the seal lips and their counterfaces in about half of the inspected bearings.

A total of five bearings out of 13 are concluded not to have seal leaks. One bearing damage is not conclusive since the service mileage is not known. The remaining seven bearings show evidence of seal leakage. It has to be pointed out, that in almost all cases, water was present in the bearing bore. Therefore it is not to be determined whether some of these seven cases may also be linked to water intrusion along the spindle.

Response
to Main Document

Achim Mueller/SCH/SKF
07/09 05:55 AM

Subject:	**Assembly Test**
Response to:	Inspection and Test Reports
Category:	

st02t207.doc

ASSEMBLY TEST

Non Rotation of THU Outer Ring

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Requested by **Requester**		
Project Project Titel		
Reported by **Achim Müller/ATT-PK**	Supervised by	Approved by **A. Stubenrauch / ATT**
Copies to		
Michael D. Lewis Achim Müller Archiv	ADNA ATT-PK MWI	SKF NATC SKF Schweinfurt SKF Schweinfurt

st02t207 1835520kB Achim Müller

Content

Tabellen und Bilder

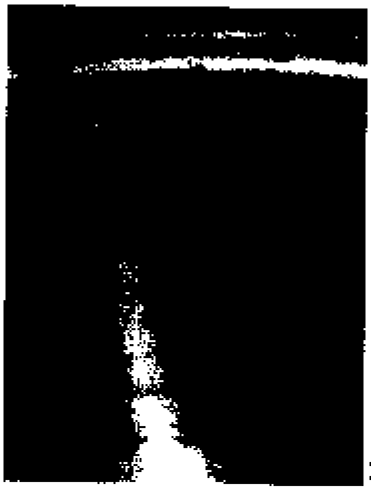
Key words: Truck Hub Unit, Assembly Test,

Purpose

Purpose of this investigation was to prove that clamping a Truck Hub Unit (THU) without rotating the outer ring may lead to damages on ring or roller raceways.

Test Description

A THU (BTF-0032) was disassembled and cleaned. The condition of the raceways was documented (see picture 1). After that, the unit was lubricated with a total of 61 gr. of GWZ grease.



Picture 1: Condition of inboard outer ring raceway before Assembly Test

The unit was put on a horizontally installed test spindle. The inner lock nut was torqued until a clamp load of approximately 90 kN was reached. Before respectively during clamping of the unit, it was taken care that the outer ring of the bearing was not rotated. As a second step, the outer lock nut was installed with a torque of 300 ftlbs. After that, the bearing was disassembled, cleaned and inspected for damages.

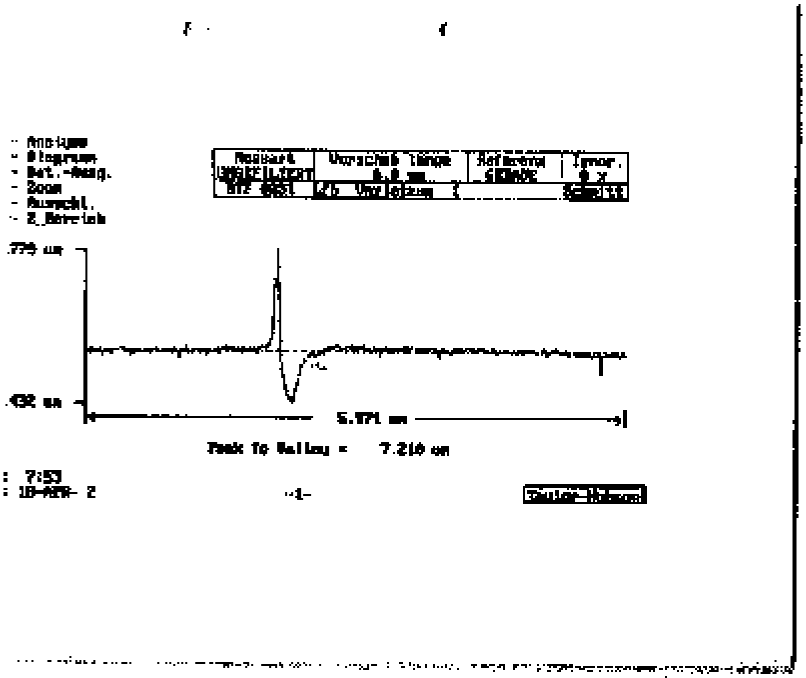
This test was repeated with three different units.

Test Results

Upon disassembly of the unit, several indentations were found on the outer ring raceways. A typical appearance form is depicted in picture 2.

Picture 2: Typical indentation on outer ring raceway after test

The extension of the indentation in picture 2 was determined to be 0.35 mm in circumferential direction and approximately 7.2 µm from peak to valley (picture 3).



Picture 3: Raceway surface and indentation

Conclusion

This test proves that non rotation of the THU outer ring during clamping can cause considerable damage of the bearing. This kind of damage is considered to be detrimental to the bearing performance.

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